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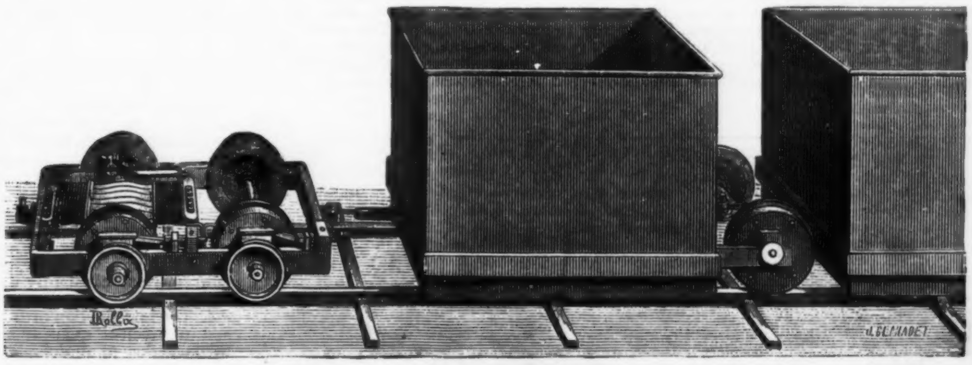
THE HIMBAECHEL VIADUCT IN HESSEN, GERMANY.

The extension of the Odenwald Railway, in Baden, Germany, called for an extraordinary number of tunnels, bridges, and viaducts, and, as a mountain railway, the extension is fully as interesting as the main line. In the accompanying engraving, one of the viaducts is illustrated. It leads over the Himbaechel valley, near Erbach, in Hessen. The viaduct is composed of ten arches, divided into three sections. The entire length of the viaduct is eight hundred and twelve feet, and its greatest height is one hundred and thirty-nine feet. Ground was broken in June, 1880, and in a year and a quarter the structure, which is built of sandstone of the trias formation, was completed.

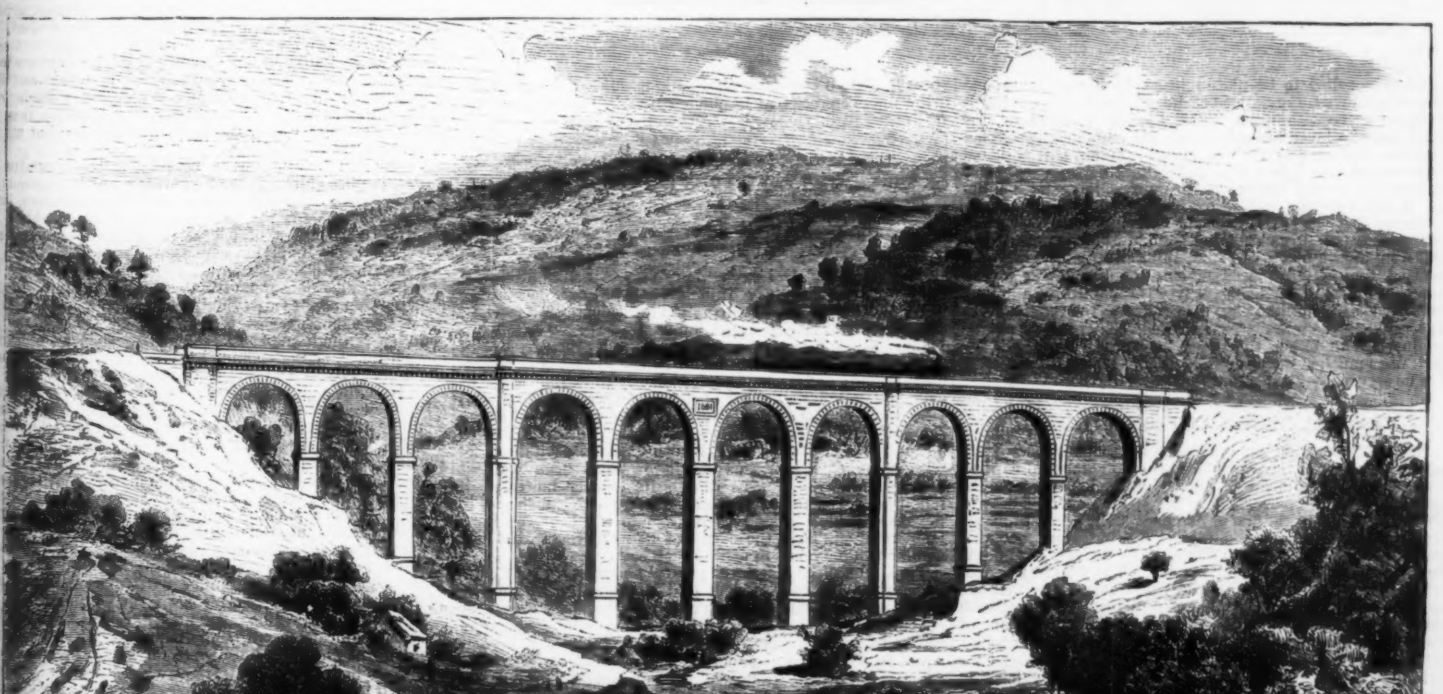
ELECTRIC POSTAL TRAMWAYS.

With the question of electric railways, properly so-called, is connected that of railways of small dimensions for carrying dispatches. The idea of replacing pneumatic tubes by a small conveyance moved by electricity was proposed as long ago as 1879, by Mr. Charles Bontemps, and then enunciated anew in a lecture by Dr. Werner Siemens. Afterward, experiments were made during the same year, and with complete success, by Mr. Marcel Deprez, on a small circular railway, constructed in the court of the Administration of Telegraphs, with the aid of his little electric locomotive. Some experiments of the same kind were performed at Vienna, in 1881, by Mr. Brunner, of Wattenvyl, and were equally successful. In spite of so encouraging results, the project that had been formed, after Mr. Deprez's experiments, of establishing an *electric postal railway* in the sewers, was entirely abandoned.

At the Palais de l'Industrie, this system of carrying postal matter and dispatches was represented by a small locomotive of Marcel Deprez and the analogous apparatus of Mr. Siemens. The first has already been described. As for the small postal electric railway of Mr. Siemens, it is represented in the accompanying cut. It consists, as the figure shows, of a small Siemens machine mounted on a little car, to whose wheels it communicates a rotary motion. The current is transmitted to the machine by the rails and wheels, and the machine carries along in its movement some metal boxes mounted on wheels, and in these are placed the dispatches.



SIEMENS' ELECTRICAL POSTAL TRAMWAY.



THE HIMBAECHEL VIADUCT IN HESSEN, GERMANY.

Mr. Deprez has shown, in some articles written by him, all the economy that would be gained by substituting electric postal cars for pneumatic tubes; and he has pointed out that, in supposing forty electric cars, each weighing thirty-three pounds, with its dispatches, to be in motion at a given instant on the lines, and to be moving at the rate of twenty feet per second, the total power required for carrying dispatches over the whole underground system of lines at Paris would be only that of twelve horses. Now, from the calculations of Mr. Bontemps, the power required at present with pneumatic tubes is that of one hundred and twenty horses.

With pneumatic tubes, not only has the box containing the dispatches to be moved, but also a considerable column of air, which causes a much greater friction than that of the box itself. A very great power, then, has to be exerted to succeed in carrying a number of dispatches, which is relatively small. With the electric post and its much smaller expenditure of power, the number of dispatches carried would be much greater. The capacity of the boxes might even be such as to fit them for carrying both letters and newspapers from office to office in different parts of the city. This would prove an important auxiliary to the postal service, and the more so in that both the postal and telegraph services are nowadays often combined.

BOILERS WITHOUT LONGITUDINAL SEAMS.

A new process for rolling weldless ring plates for boilers, with the view of avoiding the longitudinal seams which are necessarily a source of weakness in boilers constructed of ordinary plates, has lately been designed and patented by Mr. J. Windle, of Manchester, England, and formerly of the Railway Steel Plant Works, Newton Heath. In the rolling mill, which has been specially designed for this work, a fixed and a movable roller are employed. The axles of these rollers are provided with top bearings, and to enable the metal to be rolled to be placed in position and the rolled ring to be moved, the upper bearing of the movable roller is arranged to be withdrawn. This bearing is fixed on the outer end of a lever hinged to a sliding standard, connected with the carriage carrying the movable roller, and actuated by means of hydraulic cylinders. Vibrating frames are also employed, carrying two, three, or more rollers, and a number of the carrying rollers are connected by gearing with revolving shafts, so as to assist in carrying round the ring. In working out this method of rolling a hole is punched in a steel ingot or a bloom of metal, and a mandrel having been inserted, the metal is placed under a steam hammer until a rough cylinder of sufficient length is obtained, or a hollow cylinder is cast, and the ring then rolled to the requisite size and shape on the mill above described. These rings can be produced with either thickened or flanged edges, and by their use a much stronger construction of boiler, it is claimed, can be secured.—*Textile Manufacturer* (*Eng.*).

THE GALVESTON COTTON OIL MILL.

Recognizing what an opening was presented two years ago in this city for the advantageous employment of capital, a number of live business men of this city organized the Galveston Oil Company. They set about to establish suitable works, and on the first of January, 1881, began to manufacture cotton-seed oil and cake. Their factory occupies the entire block of ground bounded by Strand, Avenue A, Seventeenth and Eighteenth streets. The buildings are of brick, and are supplied with the finest machinery that can be obtained for the work. These represent an actual cash investment of $250,000, and can be justly regarded as one of the most prominent factors that go to make up the industrial prosperity of Galveston. The mills have a capacity for grinding 30,000 tons of cotton seed annually, which will produce 20,000 barrels of oil and 10,000 tons of cake. One hundred men are regularly employed, and yet, as large as these figures are, the company intend, during the present year, to make additions of buildings and machinery to the value of $50,000, which will make it one of the largest cotton oil mills in the South.—*Galveston News.*

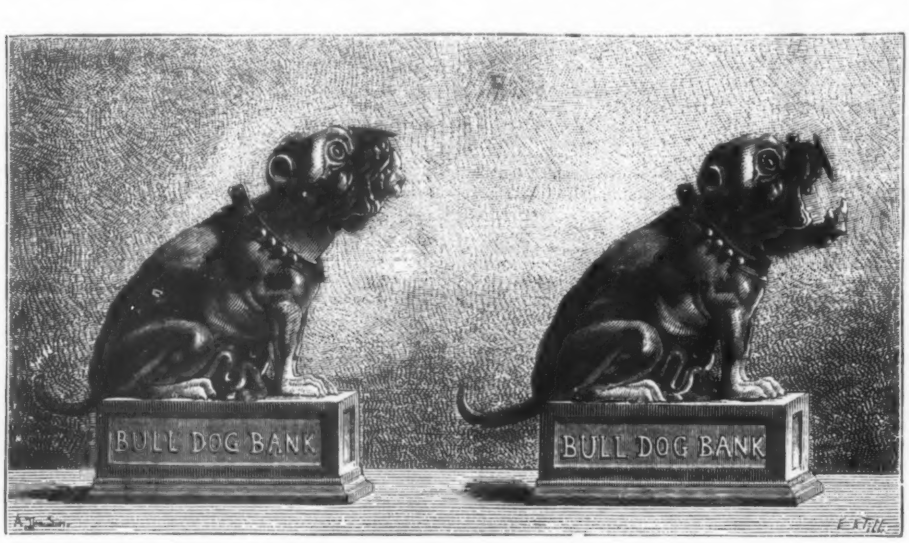
THE FASTEST ATLANTIC PASSAGE.

The official record of the recent fast passage of the Cunard steamer Servia is as follows: "3:55 P.M., January 18, passed Castle Garden; at 5:5 P.M., passed Sandy Hook, wind variable, moderate breeze; 19th, moderate breeze, distance run 268 miles; 20th, northerly breeze, 372 miles; 21st, wind easterly, moderate, 380 miles; 22d, easterly light winds, 360 miles; 23d, southerly, fresh, distance 392 miles; 24th, southwesterly winds, 402 miles; 25th, southwest breeze, 392 miles; 26th, southwest, 302 miles to Queenstown; 2:15 A.M., ship's time, passed Fastnet; 5:42, arrived at Queenstown. The apparent time of the passage is 7 days 12 hours 39 minutes; and the actual time of the passage from Sandy Hook, 7 days 7 hours 41 minutes. This is by several minutes the shortest passage on record, notwithstanding that the Cunard route is by ninety miles longer than that taken by most of the other lines. It will also be seen that on several days the Servia had easterly winds.

THE BULL-DOG BANK.

The accompanying cut represents a mechanical "savings bank," which is of English devising, and which very happily departs from the monotonous form given these receptacles for the savings of children. The "bull-dog bank" imitates very simply and ingeniously that little trick of dexterity which is so often performed by poodles and trained dogs. Only, in the case under consideration, the lump of sugar is advantageously replaced by a piece of money whose value has no influence on the final result; for gold, or silver, or bills are each swallowed with the same facility down the ever hungry throat of the mechanical canine. It is only necessary to place the money on the nose of the animal and pull his tail, and the thing is done!

The first position to the left in the cut is the position of repose, while that to the right represents the psychologic moment—the moment at which the greediness of the dog is excited by pulling his tail. This action produces three distinct motions that invariably cause the animal to swallow the money: the entire head is pulled backward, the neck enters the body, while the lower jaw opens to an immoderate degree and gives the dog a peculiar aspect of voracity. When the head has nearly reached its backward course, a small button located on the nose rises mechanically and tilts up the piece of money, which falls into the yawning jaw and slides into the animal's belly. On letting go the tail the head starts forward again under the action of a spring; the button resumes its level; the jaws close; and the animal is all ready to renew his repast. The construction of this curious toy, all of cast-iron, is likewise to be remarked. The pieces fit very simply into one another, and the whole affair is put together with a few screws. A revolving disk underneath the bank permits of an aperture being uncovered so that the money may be removed.—*From La Nature.*



[Continued from Scientific American Supplement, No. 325, page 5182.]

ON WARMING AND VENTILATING OCCUPIED BUILDINGS.

By Arthur Morin, Director of the Conservatory of Arts and Trades, Paris.*

35. *Principle of Archimedes, its effects.*—Air, like all fluids, follows that elementary principle of physics, according to which a body plunged into a fluid loses a part of its weight equal to that of the displaced fluid.

Thus, at the temperature of 32° and under the pressure of 30 inches, every cubic foot of air in the atmosphere weighs 0·081 pound; and as it occupies exactly the same space as every other volume of air of the same weight, it remains wherever it is placed, unless disturbed by an external force.

If, on the contrary, the temperature of this cubic foot of air be reduced, for example, in consequence of its contact with some cold body, as a window-pane or a wall, it contracts, its volume is reduced, its density increases, it becomes heavier than the volume of air which it displaces in the mass, which is assumed to remain at about the same temperature. Then the excess of its weight over that of a similar volume tends to make it descend.

Thus, in a place where the general temperature is 68°, if a portion which was at first at that temperature, with a density of 0·0756 pound to the cubic foot, becomes cooled by contact with a cooler body, such as a window-pane or the walls, at a temperature of 32°, its density will become equal to 0·081, and each cubic foot will tend to fall with a force equal to the excess of its new weight over that of a cubic foot of the surrounding air, or 0·081—0·076=0·005 pound. This effect is constantly produced in winter, when the surfaces of windows and walls are colder than the air of the warmed apartments.

On the contrary, if the temperature of a part of the air be raised above the mean temperature of the surrounding air, that air expands, its density diminishes, and each cubic foot, no longer weighing as much as the same volume of the rest of the air, is pressed upward by a force equal to the difference of densities.

Thus, in summer, the air in contact with the window-panes becoming warmed, and in winter the same effect being produced by stoves, lights, and even by the people in the room, the air, becoming less dense, rises toward the ceiling.

If, for example, the mean general temperature of any place is 61°, the density of the air is 0·077 pound, and if, owing to the action of the sun, the air in contact with the windows becomes raised to 79°, its density becomes 0·074, and each cubic foot of that air is forced upward by a force equal to 0·077—0·074=0·003 pound.

36. *Frequency of the preceding effects.*—The effects which we have just mentioned frequently manifest themselves in a very unpleasant way in winter, when a person is seated by a window, in a room where the general temperature is high, and still more sensibly in large halls, lighted by skylights. In the latter case, it is often necessary, to avoid these difficulties, while retaining the lights, to heat the space between the roof and the ceiling to 86° or 104° by means of stoves, examples of which will be given further on.

On the contrary, glazed ceilings, recently introduced into some theaters and palaces to admit the light from a large number of gas jets, also heat the room to a very unpleasant degree.

A similar effect is produced in summer in railroad stations, courts, workshops, and in large buildings covered with glass roofs in which sufficient ventilation has not been provided. The temperature in such places often rises to 104°, 110°, and more.

37. *Unstable equilibrium of air.*—Cooling and warming effects similar to those just mentioned are constantly taking place in dwellings, the air is never at rest, and the slightest variation in temperature and pressure produces almost endless motion. The air, then, is always in unstable equilibrium.

38. *General principles of ventilation.*—Change of air in occupied places is only rendered necessary by the alteration produced in it by respiration, bodily exhalations, the heat given out by the occupants, by the lights, or by these different causes combined. The many observations which I have made, and a comparison of experiments made by different engineers and by myself, have led me to the following conclusions, which I regard as proper to serve as fundamental principles in the formation of plans for the ventilation of occupied buildings, and especially of hospitals:

1. Ventilation is designed for the removal of foul air and the substitution of fresh air.

2. The principal object of ventilation is the immediate withdrawal of foul air. It should, in general, act as near as possible to the points where the air is contaminated by injurious exhalations, in order to prevent them from affecting the air of the rooms. Inversely, fresh air should be introduced at points removed from the occupants.

3. The different plans which act by means of a draught, when they are properly proportioned and well made, fulfill better and more surely the foregoing conditions than those which act exclusively by forcing in fresh air. The latter do not, of themselves alone, secure the removal of foul air uniformly and constantly under all circumstances and in all seasons.

4. The introduction of fresh air taken at the desired height and in sufficient quantity may be obtained in most cases by the action of draught alone, and without the help of blowing apparatus, by making the air-shafts and their openings sufficiently large, and having them properly arranged.

5. The draught may be produced, first, by the fire-places or stoves with their chimneys, which are used for general heating or by similar apparatus; secondly, by the same means, aided, if necessary, by auxiliary fires at the bottom of ventilating-shafts, fifty to sixty five feet high in large establishments, when these are needed. The air to be removed should flow toward the base of these shafts; in most cases it should be carried there through one or more channels which branch out and terminate in openings close to the sources of infection.

6. Ventilation, by means of draughts produced by grates and chimneys, is easily adapted in most cases to all the modifications rendered necessary by the size and arrangement of rooms. It approaches, as closely as could be desired, the usual and natural aeration of rooms and apartments; it allows the amount and temperature of the air currents to be varied as needed. It only requires cheap fire-places and their chimneys and pipes or channels, which, once made, cost little to keep in order. It needs no other attention than the regular supply of fuel to the fires, to which account all the attendance may be charged.

Ventilation by blowing or by mechanical apparatus requires, besides chimneys and ventilating flues, common to both systems, blowing-engines and steam-engines, with special channels for the introduction of the air-blast. It requires the attention of special laborers, mechanics, and firemen, besides involving expense for repairs.

7. For hospitals or for buildings having several floors, the blowing-system does not give the same guarantees as the other system against carrying foul air from one room to another, nor against the return of foul air through the air-shafts or through cracks in their sides, when an accidental circumstance, as the opening of doors or windows, disturbs the usual pressure and motion of the air in the rooms.

8. Draught maintained by simple fire-places and chimneys, with openings of sufficient size suitably placed for the admission of fresh air, carries off the foul air without the help of any mechanical apparatus, and becomes, except under exceptional circumstances, the readiest method of securing healthful ventilation as strong as desirable in occupied buildings, and especially in the wards of large hospitals, or in those of small hospitals capable of being warmed by an open grate.

9. As regards those establishments where it would be necessary, under special conditions, to employ mechanical methods of forcing in air, it would always be well to aid their action by a strong draught, particularly affecting those places from which exhalations are supposed to arise.

The latter case seldom occurs in establishments where ventilation must be continually maintained; the amount of air removed and introduced remaining almost always constant. When, on the contrary, this work must be frequently changed from one place to another in the same building, and when the amount of air to be changed differs very greatly from one day or hour to another, as is the case, for example, in Saint George's Hall, Liverpool, where these amounts vary from one to fifty, it may become necessary, or at least advantageous, to assist the action of the draught produced by heat, by that of a mechanical apparatus to produce a sufficient motion in the air supply pipes.

These conclusions, based upon the discussion of a large number of experiments made by several observers, have been accepted by the hospital consulting committee of hygiene and medical practice, appointed by the secretary of the interior, under an imperial decree of August 29, 1862. They apply to ventilation of all occupied places, and they serve as foundations for the special rules which we shall present.

39. *Influence of seasons.*—It is important not to forget that, in the winter, ventilation may be secured directly and at the same time as warmth. It is this, in particular, which renders warming by means of fire-places in winter so healthful. But it is proper to repeat that this natural ventilation, due to differences of temperature, which are usually quite small, is essentially inconstant, and, therefore, liable to act alternately in the reverse direction, which would often cause great trouble.

* Translated for the Smithsonian Institution by Clarence B. Young.

The simple difference of internal and external temperature, and, consequently, of the densities of the external and internal air, is then capable of producing sufficient velocity in the receiving and discharging channels to maintain the renewal of air in a proper manner. Thus is obtained what is called natural ventilation.

40. *Amount of air to be changed every hour to preserve the healthful condition of the room:*

	Cubic feet.
Hospitals:	
For ordinary cases of sickness	2,119–2,472
For surgical and lying-in cases	3,532
During epidemics	3,709
Prisons	1,766
Workshops:	
Ordinary occupations	2,119
Unhealthful occupations	3,532
Barracks:	
During the day	1,059
At night	1,413–1,766
Theaters	1,413–1,766
Assembly-rooms and halls for long receptions	2,119
Halls for brief receptions; lecture-rooms	1,059
Primary schools	42–4,530
Adult schools	883–1,059
Stables	6,357–7,063

These amounts, much larger than those deemed necessary a few years ago, are not at all excessive, and are for the most part based on direct observations.*

In manufactories and other buildings, where the number of persons is not very large, but where other causes may affect the air, the amount to be withdrawn should be determined by the condition that the air in each of these places should be completely changed a certain number of times an hour. Thus, for dwelling-rooms, this change should take place about four or five times an hour.

We will specify further on the proportions to be adopted in some other particular cases.

41. *Proper temperature.*—In well-ventilated places, with a constant change of air, higher temperatures can be easily borne, and even be found pleasant, than those which would be found oppressive where the air is not changed. Nevertheless, the internal temperature should not be kept above the following points:

Nurseries, asylums, and schools	59°
Workshops, barracks, prisons	59°
Hospitals	61°–64°
Theaters, assembly-rooms, lecture-halls	66°–68°

The fresh air introduced should generally have about the temperature it is desired to maintain in the room as soon as this is sufficiently warmed.

If, however, the room has large glass surfaces which cool the air, if there are not many occupants or lights, the fresh air should be warmer, and its temperature may be as much as 86° or 95°.

If, on the other hand, there are many lights burning and large gatherings, the temperature of the fresh air should be a little less than that of the room itself. Trial will readily determine the proper temperature in each case.

42. *Means of regulating the temperature of the fresh air.*—During the period of artificial heating, it is proper to reserve means of mixing with the warm air supplied by the heating apparatus cool air, the amount of which may be regulated by convenient registers. For this purpose the warm air supplied by the heating apparatus should be received in a special receiver or mixing-chamber, into which the cold air also enters before passing into the distributing pipes.

43. *General rules, theoretical and practical.*—Theory and experiment agree in showing that, calling—

A the sectional area of a chimney or air-shaft;
H its height;
T′ the temperature of the external air;
T the mean temperature in the shaft;
V the mean velocity of the air in the shaft;
K a numerical coefficient, constant for each shaft, and depending upon its size and position; and
Q the volume of air passing through in a second,

we have the equations—

$$V = K\sqrt{(T - T')\,H}$$

and

$$Q = K\,A\sqrt{(T - T')\,H}$$

44. *Consequences of these formulas.*—It follows from these formulas that the velocity, V, of the air or smoke in a chimney is proportional—

1. To the square root of the excess of the temperature of the gases in the chimney over the temperature of the external air;

2. To the square root of the height of the chimney, and that the volume of air or smoke discharged in a second is proportional to the same quantity and also to the sectional area of the flue.

It follows then—

1. That the velocity, V, and, consequently, the volume, Q, of the gases given off by the chimney are increased, or the draught rendered stronger by increasing the height of the chimney.

2. That the volume of gases or air removed is increased by giving a greater sectional area to the chimney.

3. That having given the height, sectional area, and general arrangement of a chimney, or any shaft whatever for air or gas, the volume of air which it will remove will always be the same if the temperature within the shaft always exceeds that of the external air by the same number of degrees.

The latter consequence, perfectly confirmed by observation, renders it necessary to proportion the heating apparatus, which produces the current for the case, when the temperature of the external air is greatest, and consequently for the summer season.

45. *Difference of temperature usually sufficient.*—Observations made in mines where the circulation of air is the most extended and complicated, as well as of ventilating arrangements of the largest hospitals and amphitheaters, show that a difference of 36° to 45° between the temperature in chimneys and that of the external air is usually sufficient to produce, throughout the air-passages, the velocities which will be mentioned further on.

In theaters, in consequence of the great number of passages, the difference should be 65° to 72° to secure the necessary discharge.

46. *Insufficiency of natural ventilation.*—It also follows from what precedes that in proportion as the difference of temperatures becomes less the velocity of the circulation of air diminishes, which explains why, if in winter the natural ventilation produced simply by the excess of the temperature of occupied places—usually kept at about 60°—over the external temperature is sufficient in most cases to secure a proper change of air when well-proportioned ventilating-flues have been put up, it is no longer so in spring and still less in summer. In these seasons, natural ventilation becomes inefficient, and, as besides it is not always possible to keep the windows open, it becomes necessary to have recourse to artificial ventilation whenever it is deemed necessary to obtain a regular change of air.

47. *Accidental reversal of the motion of the air.*—When the shafts are not kept at a sufficiently high temperature, it often happens that the motion of the air becomes reversed, and the flues introduce the external cold air instead of causing the discharge of the foul air. This effect is frequently produced in arrangements where, by the introduction and discharge of air, natural ventilation cannot be counted upon, notwithstanding the difference of height in the entry and discharge shafts. This is frequently observed in reception-halls, where, several rooms being thrown into one, the chimneys of some, being heated more or less, serve as discharge-flues, while others bring in cold air. The same effects are also produced in places which are only ventilated a part of the day, such as lecture-rooms, theaters, etc. It then often happens that the motion of the air is periodically reversed. The cold air enters by the discharge-flue, and the warmer air of the places which have been occupied escapes through the openings for the admission of air. This reversal, which produces a useless cooling effect, may be prevented by placing in the air-pipes and channels doors or registers, which may be shut when the ventilation is to be discontinued.

Finally, it is also necessary to close the communication with the places to be ventilated when starting the fire, mentioned further on, placed at the bottom of the ventilating-shaft for producing draught, so as to avoid a down-draught, as in the preceding case, filling the room with smoke. A special air-supply should be reserved for this fire.

48. *Insufficiency of window-openings.*—It is generally believed that opening the windows of a large room will produce a complete change of air, and many physicians think that in hospitals the opening of a certain number of windows placed on opposite sides will have that effect. This is not as true as supposed; and in summer, when the air is still and there is no wind, it often happens that the complete opening of five or six windows, on opposite sides of a large reception-room, coach-house, railroad-station, or riding-school, produces but a very imperfect change of air, and does not at all prevent an excessive increase of temperature. Examples of this kind are very numerous.

49. *Position of openings for the admission and discharge of air.*—None of these openings should be placed at the level of the floors as builders usually but improperly place them, because the sweepings fall in them, and soon choke the corresponding flues.

Openings arranged to admit warm or cold air should be placed near the ceiling, or at such a distance from the occupants of the room that they may not perceive any current of air.

When, on the contrary, the openings are placed near the floor the warm air in winter ascends rapidly to the ceiling, while in summer the fresh air, which is heavier, remains at the lower part. In both these cases it is unpleasant to stay near these openings. In public halls and lecture rooms especially, the admission of air under the seats and between the feet of the audience is improper. In the Palace of Luxembourg and the Chamber of Deputies this mode of introducing air has had to be given up entirely.

Discharge-openings, on the contrary, should, in general, be arranged near the floor, and also in the vertical walls. Some special cases, in which this latter rule must be violated, will be mentioned further on.

50. *Proper velocities of the air in the discharge openings.*—These velocities should increase from the first openings in the room to the chimney, which it is well to make common to all the ventilating-flues of the same house. They should be governed as far as possible by the following:

	ft.	in.	to ft.	in.
First ventilating-openings, velocity in one second	1	4	2	4
First collecting-passages	3	3	3	11
Second collecting-passages	4	3	4	7
General discharge-chimney	5	6	6	6

These velocities are easily obtained in most cases by means of an excess of 36° to 45° in the chimney over that of the external air.

51. *Sectional area to be given to openings and flues.*—The total volume of air to be discharged in a second, being calculated in advance according to the number of occupants and the conditions of change of air, dividing this volume by the proper velocity for each passage will give in square feet the free sectional area. By free sectional area is meant the actual passage-way, the gratings which often obstruct it being deducted.

EXAMPLE.—Take the case of a hospital-ward of twelve beds, to each of which is allowed 2,825 cubic feet of air an hour, making in all 33,900 cubic feet an hour, or 9·42 cubic feet a second, the mean velocity in the channels being 2·3 feet a second, their total section would be $\frac{9{\cdot}42}{2{\cdot}3} = 4{\cdot}1$ square feet. If it be necessary to have one to each bed, the pipe behind each bed should have a section equal to $\frac{4{\cdot}1}{12} = 0{\cdot}34$ square foot, and its dimensions should be 7 by 7 inches. The collecting-pipes, which receive the foul air from the six beds on each side, should discharge 4·715 cubic feet in a second, at the velocity of three and one-quarter feet a second. Their greatest sectional area should be 1·437 square feet, and their dimensions 1 foot by 1 foot 5 inches; but they should be made smaller at first, and proportioned at every point to the amount of air to be removed. The sizes of the other air-passages should be determined in the same way. If there are three stories to each wing, or thirty-six beds in all, the amount of air to be removed will be 101·710 cubic feet an hour, or 28 feet a second. The velocity in the chimney being given at about 7 feet, the area should be 4·3 square feet, and the dimensions 2 feet 1 inch by 2 feet 1 inch.

52. *Proper velocities for the air in fresh-air openings.*—When the openings are placed in the ceiling of the places ventilated, and when the air descends vertically, the velocity of the fresh air should not exceed one and two-thirds feet a second.

When the air is distributed laterally, and almost parallel with the ceiling, or at 16 to 20 feet above the heads of the occupants, the velocity of the entering air may be three and one-quarter feet without inconvenience. Such entering velocities are usually easily produced by the simple effect of the draught, which causes the removal of the air. Thus, in the large lecture-hall of the Conservatory of Arts and Trades, which often contains 750 auditors, to each of whom is allowed 1,059 cubic feet of air an hour, which requires a change of 794,610 cubic feet an hour, or 227 cubic feet a second, the total free section of fresh air openings is about 129 square feet, and the admission of this large volume of air is scarcely perceptible.

53. *Proper area of fresh-air openings.*—Although in every case a part of the air carried off will be naturally replaced by that which enters through the joints of the doors and windows, it will be well to calculate the free area of the openings for the admission of fresh air by dividing the total amount to be introduced in one second by the fixed velocity of entrance. Thus, the currents of air from the doors and windows will be diminished.

54. *Means of overcoming the effects of currents of air produced by the draught.*—The system of ventilation by direct draught is rightly charged with producing currents of air, often very unpleasant, when the outside doors are open; but the effect of these currents may be rendered less unpleasant by following the preceding rules, and, besides, they may be rendered almost entirely imperceptible by taking care to warm the entrances to ventilated buildings, such as corridors, vestibules, waiting-rooms, etc., so that the opening of doors will only cause the admission of warm air at a temperature at least equal to that of the places to be ventilated. We will specify in each case the particular arrangements to be adopted for this purpose.

APPLICATIONS.

55. *Ventilating by means of common fire-places.*—Fire-places, though not economical forms of heating-apparatus, produce a very pleasant temperature, and also serve as efficient means of changing the air of occupied apartments.

Natural draught produced simply by the difference between the temperature of the air within the chimney and that without, in many cases, carries off as much as 14,000 cubic feet of air an hour, even when no fire is burning in the fire-place.

With a coal or wood fire of moderate intensity, the amount of air carried off may be as much as 42,000 cubic feet an hour, or 2,200 cubic feet to each pound of wood burned, and 3,200 cubic feet to each pound of coal burned.

But, with this advantage, common fire-places have the serious defect of drawing in, through the joints of doors and windows, currents of cold air, which run to the fire and chill the backs of those sitting there, an effect which is particularly unpleasant when the face is very much warmed by the fire.

The various forms of apparatus in use, which are designed to warm the apartment, and, at the same time, draw in external air to increase the draught and promote combustion, usually have too small flues, and heat the air to 176°, 212°, or more, which, issuing horizontally at about the height of the occupants of the room, becomes at times unendurable. These forms of apparatus have besides the defect of obstructing the lower portion of the smoke-flue, and of reducing the volume of air carried off. Fire-places made on Douglas Galton's system, with the dimensions given in § 13, do not have these objections, and are unexceptionable means of warming and ventilating during the winter.

56. *Use of chimneys for summer-ventilation by means of gas-jets.*—Chimneys may easily be made to serve as ventilators during the summer, or on special occasions, by placing in them an iron or copper pipe furnished with several gas-burners. In the chimney of an ordinary apartment, having an earthen-ware flue 11 inches square and 66 feet high, the amount of air drawn up the chimney to each foot of gas burned will be greater the less gas is burned and the less the temperature in the flue, following pretty nearly the following decreasing series:

Amount of gas consumed an hour.	Amount of air drawn up the chimney every hour to each cubic foot of gas burned.
Cubic feet.	*Cubic feet.*
7	1,900
14	1,400
28	700
35	600
42	500
49	450

These approximate figures may serve to determine the number of three and-a-half-foot burners that will be required to produce any desired rate of change of air in an apartment.

When the chimney is much lower than that just mentioned, it will be necessary to correct the calculated volume of air in the proportion of the square roots of the heights of the flues.

The pipe which conveys the gas to the flue may be easily taken away when not in use, and closed by a blind socket.

This mode of ventilation may be employed to advantage in drawing-rooms on reception-days, provided that registers be placed at convenient points for the introduction of moderately warm fresh air.

During the summer, the system of ventilating by means of gas-jets will also allow the room to be maintained at a lower temperature than that of the external air, by drawing in the air from clean cellars to replace that carried off.

EXAMPLE.—The directors' room at the Conservatory of Arts and Trades is ventilated in this way during the summer; and, although the air from the basement is admitted through but a single opening, entirely too small for the purpose, and the doors of the room are constantly being opened, yet the temperature is always four degrees lower than the room of the subdirector, which has a precisely similar exposure, but is unventilated, and it is seven degrees lower than the temperature of the external air in the shade.

57. *Auxiliary ventilating-flues.*—For unusually large gatherings, in addition to the chimneys, additional flues may be cut in the thickness of the front or party walls, in which gas-jets may be used to produce a strong draught. This method has been tried with success in a house in the Champs Elysées, Paris.

INFANT ASYLUMS.

58. In these charitable institutions, in addition to securing space and cleanliness, provision should also be made for

* Études sur la ventilation, 1er vol.

obtaining an abundant and regular supply of fresh air, without depending upon the irregular opening of windows.

In this respect, all establishments of this kind, even the model one at the International Exhibition, fall far short. They are warmed by cast-iron stoves, the imperfections of which were shown in § 16.

As an example of what appears proper to be done in such cases, I will describe the plan carried out in the new asylum in the parish of Saint Ambrose in Paris, the construction of which was intrusted to M. Picq, the architect (Fig. 14).

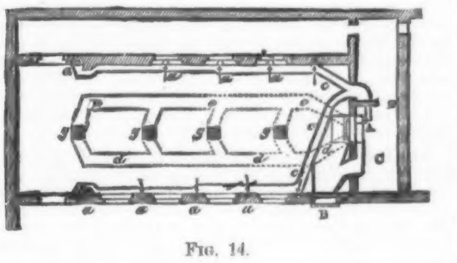


FIG. 14.

This asylum is intended to receive fifty babies. There will also often be twenty-five mothers there at a time, while the attendants and patronesses present will usually add ten persons more.

With these data, the maximum volume of air to be carried off and replaced by fresh may reach the following figures, (§ 40):

	Cubic feet.
For 50 babies (530 cubic feet each per hour)	26,500
25 visiting mothers (1,060 cubic feet each per hour)........	26,500
10 attendants (1,060 cubic feet each per hour)..	10,600
Total amount of air to be changed every hour .... or 18 cubic feet in a second.	63,600

This amount greatly exceeds the actual requirement, because the regulations of the asylum forbid the presence of the mothers in the main hall. They are received and nurse their children in a special apartment.

The main room is 61 feet long, 24 feet wide, and 15 feet high, having, therefore, a content of about 22,000 cubic feet. With the amount of air mentioned above, the complete change would take place in $\frac{63,600}{22,000} = 2{\cdot}8$ times an hour, which is quite sufficient to keep the room in a healthful condition.

The room is warmed by a hot-air heater, with vertical cast-iron tubes, having altogether about one hundred square feet of heating surface, communicating with a cold-air duct, which will be described hereafter.

It was intended that this heater should have two chambers: the exterior one, for drying damp linen, carrying the vapor to the chimney; the interior one, opening into the room, for warming dry linen. On account of the expense, these chambers were not made.

There might easily have been placed around the fire-chamber in this heater hot-water pipes connected with a receiver, in order to furnish a supply of water for domestic use.

In summer, the receiver, which, indeed, might have been placed in the chimney-flue, could have been heated by a special fire. This useful appendage was given up for the same reason as the other.

The foul air is carried off through ten flues, *a, a, a* (Fig. 14), made in the thickness of the walls. The required velocity of the current being 2·3 feet a second (§ 50), the clear sectional area of each flue has been fixed at $\frac{18 \text{ feet}}{10 \times 2{\cdot}3} = 0{\cdot}78$ square foot.

The size of the openings might then be one foot by nine inches; but, their area being reduced by a register which cuts off about one-third, they have been made one foot square.

These flues open into collecting-flues arranged under the floor on each long side of the building; each of these collectors being able to carry off at a maximum nine cubic feet a second, with a mean velocity of three feet a second (§ 50). They have at their mouths a sectional area of 2·7 square feet, being about nineteen inches square; but, at the first part, up to where the third down-flue enters, their areas have been reduced each to 1·6 square feet, they being one foot by twenty inches.

The transverse collectors, *c, c*, in which the air should have a velocity of four feet a second (§ 50), have each a sectional area of only two square feet in their transverse portion, being one foot four inches by one foot seven inches, and they are but two feet seven inches by one foot seven inches where they enter the chimney, while there they should carry off eighteen cubic feet a second.

The chimney, which should carry off eighteen cubic feet a second at the velocity of seven feet a second (§ 50), should have the area $\frac{18}{7} = 2{\cdot}57$ square feet, or be one foot seven inches by one foot seven inches. It really has a sectional area of five square feet, which is larger than necessary. It contains the smoke-flue, and it has, near the bottom, a little grate ten inches by ten inches, forming a heater, in which a little coal-fire may be made in mild weather in order to keep up the circulation of air.

The introduction of fresh air is made in accordance with the rules given in §§ 51, 52.

The fresh-air supply for the heater, A, is obtained by means of a pipe, B, carried from the garden and passing under the floor. At its outer end, this pipe is connected with a sort of chimney connected with a grating to prevent the introduction of foreign bodies.

The air to maintain the draught of the fire is taken from the little room, C.

The warm air supplied by the heater passes to the upper room by pipes, *d d d, e e e*, placed under the floor of the attic-room in the line of the building. The construction of the roof did not permit of using only a single pipe, which would have been sufficient. The cold air to be mixed with the warm air is taken in the upper room, where it is deflected toward the pipes by means of slats, so as to be delivered above the warm air pipe, *d d d*.

A shelf fastened to each side-wall at half the height of the longitudinal pipe, *e e e*, secures the separate admission of hot air below and cold air above. It is sufficient that these shelves be ten or twelve feet long, but they should be made of earthenware, in order that they may not be too much heated by the action of the air from the heater, which might prevent the entrance of the cold air.

The two pipes for warm and fresh air are twelve inches by twenty inches. Four openings, *g, g, g, g*, placed in the ceiling in the center line of the room, admit the mixture of warm and fresh air with a velocity of about twenty inches a second (§§ 51, 52), and in order to allow for the obstruction of the grating they are made twenty-eight inches by thirty-five inches. Registers are placed at the lower part of the chimney to regulate the amount carried off, and they are also placed in the warm-air and fresh-air pipes so as to obtain the proper mixture.

Such are the simple and inexpensive arrangements which serve to maintain in this asylum a degree of healthfulness superior to that of other establishments of the kind.

59. *Results of experiment.*—The plan just described was carried out, with a few modifications in details rendered necessary by local conditions and by work previously done. The asylum was opened January 27, 1868, and experiments made there in the first part of February, which gave the following results:

Results of experiments made in Saint Ambrose Infant Asylum.—The inside work of this asylum was not finished till the latter part of January, and the hall was opened on Monday, the 27th, to the first children that were presented. After three or four days of heating to bring the interior to the proper temperature, the experiments were begun on the 31st January.

In the first visit to the hall, it was noticed that the foul air was carried off very well by all the openings, although the velocity appeared considerably greater at those nearest the chimney, as is natural. It would be easy to render the amounts carried off through the openings more uniform, if deemed necessary, by placing a register at each opening and regulating it once for all.

The admission of fresh air is provided for by means of openings in the ceiling, and its velocity does not exceed eighteen or twenty inches a second. It can be rendered entirely uniform by partially closing the openings furthest from the heater, but this is not necessary.

The amount of air admitted into the heater to be warmed may vary greatly according to the intensity of the fire, but, with the very moderate consumption of fifty-seven pounds a day, it was found to be, on the 6th of February, 62,000 cubic feet; and on the 7th of February, 59,000 cubic feet, raised from the external temperature, 42°, the usual mean temperature of the winter, to 88°, at which it was admitted into the room. The heater, on account of the large dimensions of its chambers, was more than sufficient alone to supply the room in winter with fresh air heated to a comfortable degree. The additional fresh-air ducts would then be often found unnecessary, and might be closed.

The amount of air brought into the room through the openings in the ceiling was found the same day, February 7, to be equal to 60,000 cubic feet an hour, confirming the previous opinion.

The amount of foul air carried off by the ventilating-chimney was as much as 65,000 cubic feet the same day and under the same circumstances. The mean temperature in the chimney was—

February 6..................................	84°
That of the external air being................	44°
Difference....	40°

Thus, with this mean winter temperature, that of 61° was maintained in the room, and, with an excess of 40° in the chimney over that of the air, almost 63,000 cubic feet of foul air was carried off, as has been stated.

The consumption of fuel an hour was—

	Pounds.
For heating........	7
For the ventilating chimney..............	3
	10

The babies being left in the morning and taken away by their mothers in the evening, it will be sufficient, in ordinary weather, if the fires be kept up at most eight hours a day. The daily consumption will then be on a mean $10 \times 8 = 80$ pounds a day.

The fuel used is composed of 75 per cent. of coke and 25 per cent. of coal, and it will be estimating it above its value to charge it at $10 a ton. The expense of fuel during the winter would then be at most $\frac{80 \times 10}{2{,}240} = 36$ cents a day, or $36 for 100 days, to obtain a change of air at the rate of 63,000 cubic feet an hour.

During the season when artificial heat is not required, the ventilating-fire alone should be used, and will usually burn not more than about three-and-one-third pounds of coal an hour, or twenty-seven pounds a day, for the period when the opening of windows will not be sufficient, or during 200 days, $\frac{200 \times 27 \times 10}{2{,}240} = \$24$. The total annual expense would then be at most $60 for an asylum which, though intended for but fifty children, might easily receive 100 in the large well-ventilated apartment, which has a content of 23,000 cubic feet, giving, in that case, 230 cubic feet for each child; while in the primary schools of Paris there is allowed, on an average, but about 155 cubic feet to each child of from six to twelve years of age.

Under these conditions, the ventilation of 63,000 cubic feet for 100 beds, or 230 feet a bed, an hour would be almost double what is necessary, and could easily be reduced to 42,000 cubic feet an hour. But even supposing that it be kept as it is, the mean expense for each child would be at most sixty cents a year.

It should be added that, without urging the ventilating-fire, it is easy, with the proportions adopted, to increase the amount of air removed to more than 88,000 cubic feet an hour.

In conclusion, we see from these experiments that the dimensions adopted in this first application to infant-asylums are much larger than necessary, and that the results intended have been more than realized. It may then be considered certain that in making similar arrangements, even with smaller dimensions, all requirements for good and complete ventilation will be satisfied at an expense much less than that incurred in the asylum which the parish of Saint Ambrose owes to its venerable curate, M. Langenieux.

60. *Proportions for an asylum of fifty cradles.*—According to the results of the experiments which have just been mentioned, and the conditions of service imposed by the regulations, the arrangements adopted by the Saint Ambrose Asylum greatly exceeding the necessities of the case, the following data may be assumed for a similar asylum:

Amount of air to be carried off and replaced for fifty children, at 530 cubic feet each per hour.	26,500	cubic feet.
For attendants and visitors	8,800	" "
	35,300	" "
Floor room, 16¼ feet to each cradle.....	812	square ft.
Interior height	13	feet.
Total cubical contents..................	10,600	cubic feet.

Equivalent to 212 cubic feet to each cradle.

The air of the room should be changed $\frac{35{,}300}{10{,}600} = 3\frac{1}{4}$ times an hour.

The volume of air to be carried off and replaced in a second would be $\frac{35{,}300}{3{,}600} = 9{\cdot}8$ cubic feet.

From these data, following the preceding rules in the calculation of the dimensions of openings and flues, all the expenses of founding and carrying on the establishment will be kept within narrower limits than those which have attended its first application.

PRIMARY SCHOOLS.

61. The plans adopted should be designed to carry off and replace a volume of 400 to 500 cubic feet an hour for each child.

The ventilating-openings should be placed in or against the vertical walls of the two long sides of the room. It is only in case of great constructive difficulties that they may be confined to a single side. There should be as many of them as possible, and they should have a clear cross-sectional area that will give to the air carried off a velocity of more than twenty-eight inches a second. They should connect with descending flues leading in the cellar or under the floor to a collecting-pipe, which, in most cases, should be carried directly to the foot of the ventilating-shaft.

The latter should be placed for its whole length beside the smoke pipe of the heater, the heat from which will assist the draught. But this heat will not usually be sufficient to give proper activity to the draught even when the external temperature is very low, and it will be necessary to keep up a little coal fire at the bottom of the ventilating shaft in a grate detached from the walls.

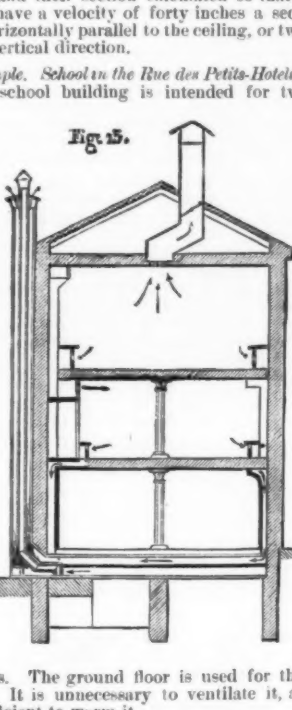
If local arrangements prevent making the fire at the bottom, it may be made at the floor level or at the top, keeping the ventilating openings, however, in the vertical walls and near the floor.

The fresh air, warm or cold, should be admitted near the ceiling, and preferably parallel to its surface. In the season for fires, the air supplied by the heater should be mixed with the external cold air. The proportion of each may be regulated by means of registers easily controlled from the interior of the room, so that the mixture may have only the temperature of 85° to 95° at most.

The fresh-air openings should be arranged, if possible, along the whole length of the room, or at least be very numerous, and their section calculated so that the entering air should have a velocity of forty inches a second, if it is directed horizontally parallel to the ceiling, or twenty inches, if it has a vertical direction.

62. *Example. School in the Rue des Petits-Hotels, Paris* (Fig. 15).—This school building is intended for two perfectly distinct uses. The ground floor is used for the children's play room. It is unnecessary to ventilate it, and a single stove is sufficient to warm it.

Fig. 15.



The second floor is occupied by the primary school kept by the Christian Brothers, and is divided into four rooms, intended for four hundred children. The capacity of these rooms corresponds to a mean of 155 cubic feet for each child, which is about the proportion adopted by the city government, and seems to us totally insufficient; 250 to 280 cubic feet for each child appears the proper amount, especially as many schools for children are used in the evening as schools for adults.

The third floor is devoted to a drawing school under the charge of a private professor, and contains two hundred and seventy desks, of which two hundred are in the main room, which, in the evening, is lighted by ninety gas burners. The capacity of this room corresponds to 200 cubic feet to each person.

Ventilation in the two rooms during the day is limited to 350 cubic feet to each person, which necessitates the renewal of 140,000 cubic feet an hour in the second story and 70,000 cubic feet an hour in the third story.

The rooms are warmed by two heaters found by direct experiment to have a heating capacity equal to eighty-one per cent. of the heat generated by the fuel,* and having proportions corresponding to 4½ square feet of heating surface for every 1,000 cubic feet of room area, supposed to be ventilated by a complete change of air twice an hour.

* Annales du Conservatoire des arts et métiers, 6e vol., p. 325.

The warm air is carried to each floor by three vertical flues leading into a large and long pipe extending throughout the whole length of the rooms, which receives fresh air from without in order to regulate the temperature of the air admitted into the room. This air enters horizontally near the ceiling.

The volume of warm air, at a temperature of from 140° to 150° ascending in the flues before being mixed with cold air, was found to be, in the second story, 106,000 cubic feet an hour; in the third story, 73,000 cubic feet an hour; and this has been found sufficient to maintain in the rooms a temperature of from 60° to 70°, when that of the exterior air was 35° or 40°.

According to the instructions given to the builder, the foul air should have been carried away from the second story by thirteen flues, the proportions of which had been determined by applying the rule adopted in § 51, which fixes 28 inches a second as the velocity which the foul air should have in the first series of ventilating flues, as indicated in the following table:

SCHOOL-ROOMS, (SECOND FLOOR.)

Numbers of the rooms.	Estimated number of students.	Volumes of air to be carried off— In an hour.	In a second.	Total sectional area corresponding to a velocity of 28 inches a second.	Number of flues and prescribed dimensions.	Total prescribed sectional area per room.
1	80	32,000 cubic feet.	9 cubic feet	4 square ft	1 of 1 foot . inches = 1 foot = 2.6 sq. ft.; 1 of 1 foot 1 inch = 1 foot = 1.1 sq. ft.	3.7
2	60	21,000 cubic feet.	6 cubic feet	3 square ft.	3 of 1 foot 1 inch = 1 foot = 1.1 sq. ft...	3.3
3	120	39,000 cubic feet.	11 cubic feet	5 square ft	4 of 1 foot 1 inch = 1 foot = 1.1 sq. ft...	4.4
4	160	49,000 cubic feet.	14 cubic feet	6 square ft	4 of 1 foot 5 inches = 1 foot = 1.5 sq. ft...	6
	400	141,000 cubic feet.	40 cubic feet.	18 square ft		17.4

ART-SCHOOL, (THIRD FLOOR.)

	80	72,000 cubic feet.	20 cubic feet.	9 square ft.	4 of 1 foot 5 inches = 1 foot = 1.5 sq. ft.; 3 of 1 foot 1 inch = 1 foot = 1.1 sq. ft..	6; 3.3
						9.3

Annales du Conservatoire des arts et métiers, 6e vol., p. 325.

Note.—The builder actually gave smaller sectional areas to the flues; still the intended results have been secured.

In the first series of collecting-flues in each story, where the velocity is to be 39 inches a second, the sectional area should be—

	Square feet.
For the second story, amount to be renewed in 1 second = 39 cubic feet, sectional area......	12
For the third story, amount to be renewed in 1 second = 20 cubic feet, sectional area......	6

In the two collecting-flues terminating at the bottom of the general ventilating-chimney, the required velocity being 4 feet a second, their total sectional area was fixed at—

	Square feet.
For the second story..................................	10
For the third story....................................	5
	15

The latter flues carry the foul air to the bottom of the chimney, which is 56 feet high, and has a sectional area of 11 square feet. The two smoke pipes being each 8 inches in diameter, or 2 feet in circumference, and having consequently 56×2=112 square feet of surface exposed to cooling, were not able, even in ordinary weather, to sustain the draught of the chimney, and a small auxiliary fire was deemed necessary. To this was given a surface of about 100 square inches, which, when burning 3½ pounds of coal an hour, carried off, on an average, 140,000 cubic feet of air an hour in the second story, and 70,000 in the third story. If the dimensions of the ventilating-flues given to the builder had been followed instead of being reduced to 16 square feet in the second story and 8 in the third, it is evident that the amount of air carried off would greatly exceed the prescribed amount, which shows that the rules which have been given allow for even serious defects in construction.

The observations made in this building in regard to the results of warming and ventilation lead to this important conclusion, that with well-made heaters and a properly arranged system of ventilation, school rooms with 350 cubic feet of air to each pupil may be comfortably warmed and ventilated by the use of no more fuel than is required for the injurious heat obtained from the cast-iron stoves used in most schools.

ADULT SCHOOLS.

63. Similar plans should be adopted for adult schools; the only change to be made consists in increasing to 500 or 700 cubic feet the amount of air to be carried off every hour for each person; or, in other words, to increase the size of the foul and fresh air flues.

NIGHT SCHOOLS OF DESIGN.

64. These present a peculiar difficulty in changing the air and moderating the temperature, in consequence of the large number of lights or gas-burners which they contain, which often produce a degree of heat in excess of that necessary to warm the room.

The general rule, which requires that the foul air should be drawn off near the floor, cannot be exclusively followed without causing currents of air heated from 85° to 95° to fall upon the students. It is, then, necessary to carry away the hot gases, the products of combustion, through the ceiling. But at the same time it is necessary to admit the fresh air, which in that case must be cool, at a certain height as far as possible from the floor.

But if the same room should also be occupied during the day as a study or drawing-room, and if it were then ventilated according to the usual rule by drawing the foul air off near the floor, it would be well at night to maintain that ventilation in order to assist the circulation and the descent toward the floor of a part of the fresh air brought in, of which, to make up for the heating effect of the lights, there should be a much greater amount than during the day.

Observations made in a school of design in Paris attended every evening by two hundred to two hundred and forty scholars, and lighted by 90 gas jets, consuming together 320 to 350 cubic feet of gas an hour, led for this special case to the following rules:

1. During the day, regulate the amount of foul air drawn off at the floor-level to about 530 cubic feet for each adult scholar, and admit the fresh air near the ceiling.

2. For night sessions, make escape-openings in the ceiling, the clear area of which should be calculated at about 88 square inches for every 1,000 cubic feet capacity of the room.

If there is no loft above the room in which the ventilating pipes can be carried, special pipes may be placed at convenient points, removed as far as possible from those at which the fresh air is introduced. These pipes should be supplied with convenient valves, in order that they may be closed during the day, and the amount of the hot gases removed at night regulated.

3. Place in the two opposite walls of the room, or at least in one of them, at the height of 10, 13 feet, or higher, if possible, as many fresh-air openings as convenient, each supplied with a regulator to direct the air horizontally near the ceiling, the dimensions of these openings being calculated so that the volume of air admitted may be increased to six or eight times the total cubical capacity of the room, with an entering velocity of but 2 or 3 feet a second.

By means of these arrangements, drawing schools may be made comfortable at night, which at present are almost like furnaces, and in which it becomes necessary to open some of the windows even in winter, notwithstanding the discomfort which may be experienced in consequence by the scholars nearest to them.

In the drawing school just mentioned, the total amount of air carried off every hour was:

	Cubic feet.
April 4, 1866	367,600
April 6, 1866	430,000
Mean	398,800

which corresponds to a total renewal almost eight times an hour.

By means of this active ventilation, the temperature in the room has been maintained till ten o'clock at night at 67° to 70° at five feet above the floor, and at 75° on an average at the ceiling, while, before the introduction of the means of ventilation mentioned above, it was, respectively, at the same heights, 80° and 90°.

65. *Plans to be adopted in schools already built.*—It too often happens that no plan has been provided in schools, and especially in night-schools, to produce even a partial change of air or to regulate the temperature, so that a stay in them is as unhealthful as it is unpleasant. There is, then, as we have said, no resource but to open the windows, and this is both uncomfortable and injurious to the scholars seated near them. These defects may, however, be removed, at least in part, in most cases by adopting the arrangements described in § 64 in the case of a drawing-school.

In order to carry off the hot gases arising from the lights, and prevent them from affecting the scholars, ventilating

SUGGESTIONS IN DECORATIVE ART.—DECORATIONS AND FURNITURE DESIGNED BY F. WIRTH'S SONS, STUTTGART. FROM THE WURTEMBERG EXHIBITION IN STUTTGART, 1881.—*The Workshop.*

openings should be placed near the ceiling. A number of ventilating-flues should be cut, the size of which may be calculated by the preceding rules; if possible, making them so large that the air may be renewed four or five times an hour. If, however, it is only possible to make one flue, it should be connected by means of a horizontal pipe, with a series of orifices in one of the long sides of the room. At the bottom of this flue should be placed either a little grate or three or four gas burners, each consuming about four cubic feet an hour, in order to keep up the draught when the external temperature is too high for natural ventilation to be effective. The use of gas is in most cases of this kind more convenient than a coal fire.

On the side opposite to that by which the foul air is carried off, a number of ventilators should be put in place of the upper panes of the windows, and arranged so as to be opened more or less as needed, in order to admit the fresh air as near as possible to the ceiling. By increasing and suitably arranging these openings, the injurious effects from the entrance of cold air will be avoided.

Arrangements of this kind have been recently adopted in the school at Saint Martin's Market, kept by the Christian Brothers, where there are about one hundred scholars in the drawing-room every evening, light being furnished by a great many gas burners. Simple wooden pipes carried up to the roof, and the employment of a few gas burners, prove sufficient to carry off the foul air and gas, and indirectly to draw in fresh air through the ventilators placed on the opposite side to that by which the foul air is removed.

These means are far from being perfect, but their employment in school buildings already built is almost always easy and inexpensive.

(*To be continued.*)

SULPHUR MINES OF SICILY.

The mining industry of Sicily is entirely confined to the production of sulphur, in which mineral the island is very rich. The sulphur country lies to the south of the Madonia chain of mountains, embracing nearly the entire provinces of Caltanisetta and Girgenti to the seaboard, and part of that of Catania; in addition to these, there is a group of mines in the south of the province of Palermo. The principal centers of this industry are at the mines of Caltanisetta, Castrogiovanni, Montedoro, San Cataldo, Serradifalco, Sommatino. Valguanera, and Villarosa, in the province of Caltanisetta; Aragona, Casteltermini, Cattolica, Cianciana, Comitini, Favara, Grotte, and Racalmuto, in the province of Girgenti; and Lercava in that of Palermo. Vice-Consul Rose states that sulphur is met with at a great variety of depths below the surface of the land, in seams varying considerably in thickness. In very rich lands the veins do not average more than 6½ to 27 feet in thickness, with sterile strata, from a few inches to three feet and over, intervening, while in those less productive, the sulphur seems to lie separated by barren strata of much greater density. The rock containing the mineral is detached from the mass by the use of a sharp pointed pickax, weighing about fifteen pounds, and brought to the mouth of the shaft, which is like an inclined plane running down the earth with steep steps roughly cut in the rock, forming, almost invariably, the only means of access to the works at the bottom of the mines. The ore is excavated by men, assisted by small gangs of boys working under them, who carry heavy pieces of the rock to the surface, as it is broken up by the miners, and deposit them in localities allotted to each pickman, where the ore is piled up in large heaps preparatory to its being measured, to ascertain the quantity of "cassa" excavated by each man. The "cassa" is the measure by which the quantity of sulphur ore dug in Sicilian Mines is reckoned when paying the miners for their labor, but differs in dimensions in different mining districts of the island. The boys employed in transporting the mineral carry from forty to sixty pounds weight, according to their ages, which range form ten to eighteen years, from pits often over 275 feet deep, making twenty to forty journeys a day. Water is frequently met with before reaching a seam of sulphur, and up to the present it has been one of the greatest obstacles in the way of mining engineering in Sicily, greatly increasing the cost of working. The depth of 190 feet is rarely obtained without water oozing through imperceptible fissures in the rock, and this frequently stops all operations by submerging the works. To provide against this, the old-fashioned hand pump was used, and this gradually giving way to steam power, has reduced to a minimum the fear of mishaps occurring by flooding. It is very rarely that any explosions occur in the Sicilian Mines, small earthenware lamps containing oil—the flames of which are left naked—being used in the mines without the slightest apprehension of accidents happening. Safety lamps are not known in Sicily. The following is the method employed in smelting the ore, after it has been separated from the rock by heat or steam. When a sufficient quantity of the ore is collected on the surface to form a pile—called, with the masonry built round it to keep the liquid sulphur from escaping, a "calcarone"—the mass, which is heaped up high, is set fire to by igniting straw impregnated with sulphur placed on the top of the calcarone, or kiln, for the purpose, and the kiln left to burn, the sulphur once ignited acting as its own fuel. From seven to eight days after the first sulphurous fumes are emitted, which indicate that the mass has caught fire, and when ample time has been allowed for a certain quantity of the ore to melt, the masonry mentioned above is pierced, and the liquid sulphur, of a deep amber color, is permitted to run out into square wooden moulds, called "balate," the sulphur, on cooling, hardening and turning to a bright yellow. The fusing by this process, in which only a small quantity of the ore is lost, may last from thirty to ninety days, the time occupied depending on the size of the kiln. There are seven qualities of sulphur known to the trade—first quality, best second, good second, current second, best third, good third, and current third. The several qualities are not determined by test, but simply by the purity of color; the brighter the yellow, the more free is the quality considered of extraneous matter. The total quantity annually smelted may be estimated at 390,000 tons, and its value when distributed at the shipping ports of Palermo, Catania, Licuta, Porlo Empedocle (Girgenti), and Terranova, at £1,765,000. The wages of miners, and others engaged in the production of sulphur, range from one shilling and fourpence to two shillings per day of six to eight hours. Pickmen are almost invariably paid according to the quantity of mineral they excavate.—*Journal of the Society of Arts.*

THE SIBERIAN GOLD MINES.

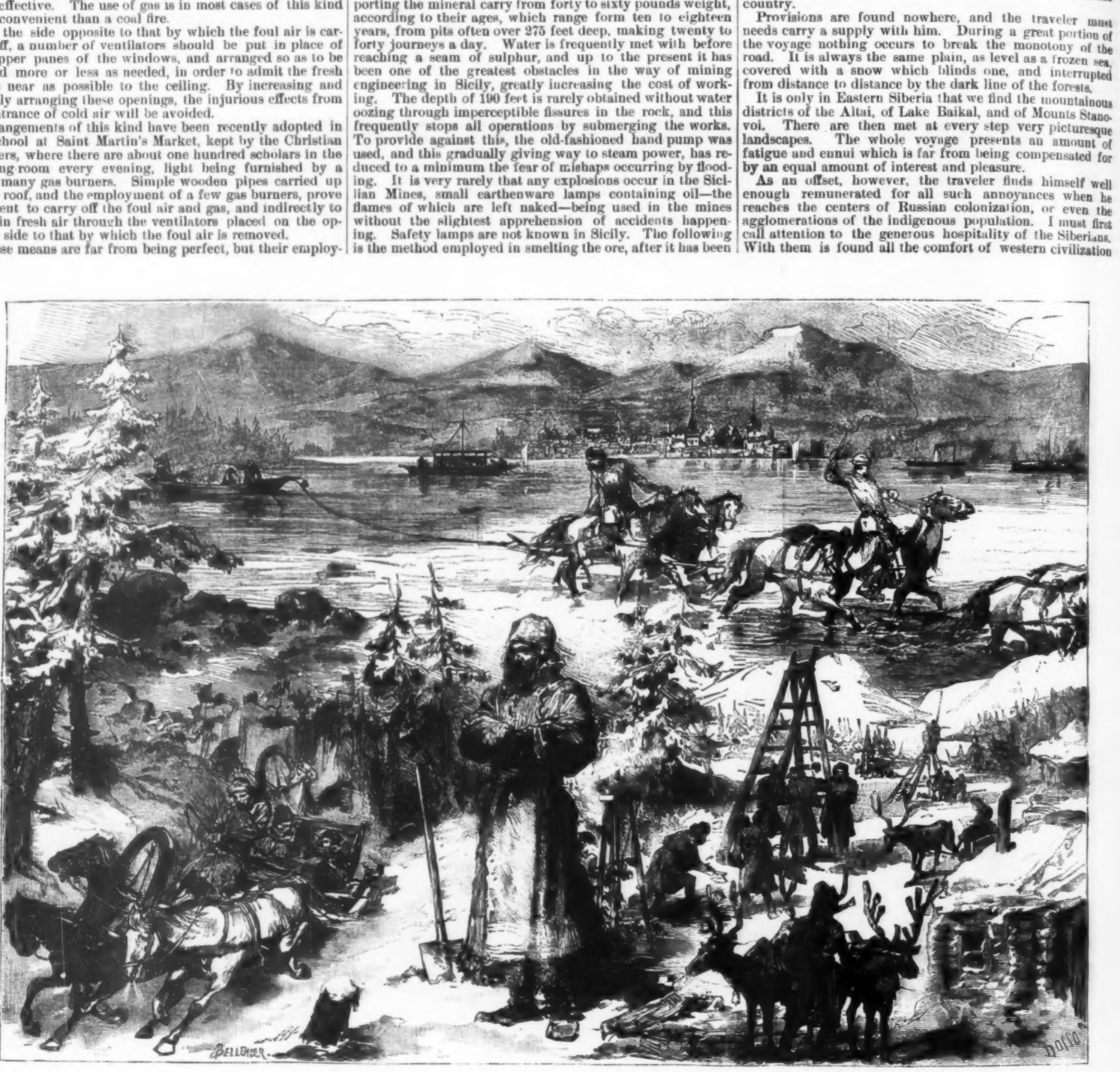
[We borrow from *L'Illustration* the following interesting account, by Mr. Martin, of an expedition made by him to Siberia, for the exploration of all the auriferous deposits of that little known region. One of the points reached by the author was but a short distance from the place where the shipwrecked survivors of the Jeannette expedition landed.]

It is impossible for me, says the author, to detail here the immediate difficulties of a voyage like this. The three chief obstacles are the distance, the climate, and the state of the country.

Provisions are found nowhere, and the traveler must needs carry a supply with him. During a great portion of the voyage nothing occurs to break the monotony of the road. It is always the same plain, as level as a frozen sea, covered with a snow which blinds one, and interrupted from distance to distance by the dark line of the forests.

It is only in Eastern Siberia that we find the mountainous districts of the Altai, of Lake Baikal, and of Mounts Stanovoi. There are then met at every step very picturesque landscapes. The whole voyage presents an amount of fatigue and ennui which is far from being compensated for by an equal amount of interest and pleasure.

As an offset, however, the traveler finds himself well enough remunerated for all such annoyances when he reaches the centers of Russian colonization, or even the agglomerations of the indigenous population. I must first call attention to the generous hospitality of the Siberians. With them is found all the comfort of western civilization



1.—Postal Boat ascending the Lena, drawn by horses. 2.—Winter: Sleighing. 3.—Mr. Martin in his traveling costume. 4.—Boring in the Mts. Stanovoi.

THE GOLD MINES OF SIBERIA.

—that comfort that is so well understood by the Russians, who are a practical and refined people, and connoisseurs in everything concerning the welfare and pleasures of life. Then we are restored to that current of intellectual movement so dear to civilized man; for, in many of the inns are found the journals, reviews, and new publications of Russia and other countries. And then again, near the centers of colonization are found the industrial establishments, the counting rooms of commerce, the mineral or agricultural explorations, and, in a word, the movement, the material life of this rising country.

The principal cities of the basin of the Lena are: Kirinsk, at about 7,000 kilometers from Petersburg, the chief place of the district, and center of commerce between Iakoutsk and St. Petersburg; Vitimsk, the extreme point of navigation up the Lena; Alokma, a locality which, like the preceding, is situated in the vicinity of the workings of the auriferous deposits; Iakoutsk, chief town of this vast territory of 4,000,000 square kilometers, and 232,000 inhabitants, and containing a population of 5,000 persons.

Iakoutsk is located in the middle of the basin of the Lena, and on the right bank of the river. It is a pretty dull sort of village, with great narrow and straight streets lined with small wooden houses. The churches alone, with a few public establishments, are of brick. The population consists of Siberians, which includes Russians who have settled in Siberia, as well as the indigenous Iakoutes and Tongouses. Among the latter is found a few who have become rich by trafficking with the workmen of the mines. The upper basin of the Lena is a very picturesque country and a very wild one, and is covered with forests. A few portions are cultivated by the Bouriates, who also are employed in raising

cattle. The principal means of communication between Iakoutsk and Russia is by the stage-coach, relays being established at every twenty-five versts along the route. As the telegraph ends at Irkoutsk, dispatches are sent to this town by postboys on horseback. These perform the journey in three weeks; and, as the distance between Iakoutsk and Irkoutsk is 3,000 kilometers, the dispatches travel from 35 to 40 leagues per day, on a good road. The mail goes more slowly, leaving Iakoutsk every week and reaching Irkoutsk in thirty days. Travelers move more slowly yet, notwithstanding their outcries, their menaces, and the foolish pourboires that they give the station superintendents. In summer the postal service as far as Iakoutsk is performed by boats, hauled by horses up the river, but rowed by the postilions down the stream.

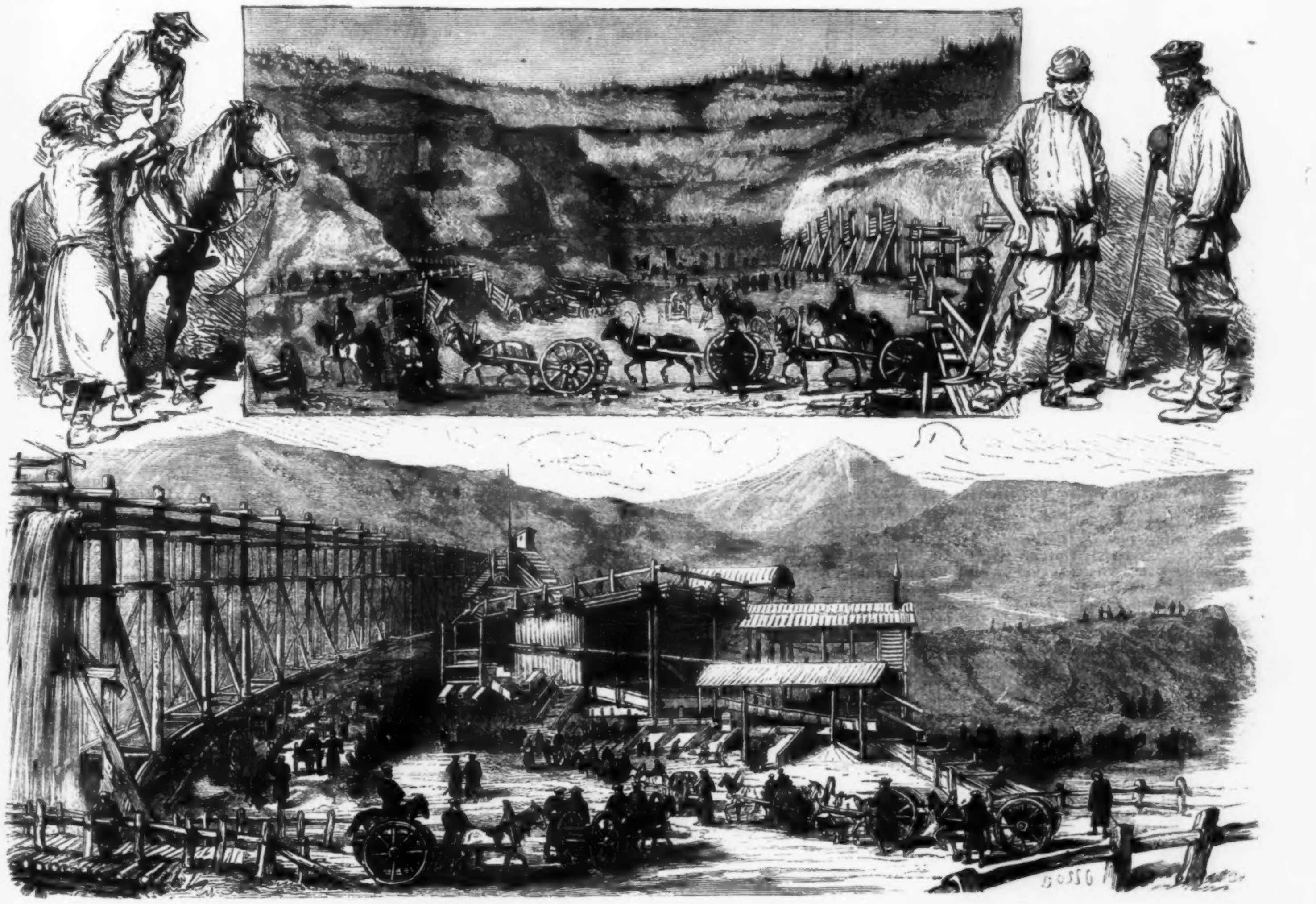
As will be seen from this, means of locomotion are still very primitive on the imperial route which puts the capital of the empire and that of Eastern Siberia in communication. And what must it be then when the highway is left in order to penetrate to the interior of the country? However, a few steamboats have already troubled the limpid waters of the Lena. One of them is La Lena, which made part of the expedition of Prof. Nordenskiold, and reached, under the Swedish flag, the mouth of the river whose name she bears. The banks of the Lena are very beautiful and picturesque, especially above Iakoutsk. The river itself presents a phenomenon which is curious, and perhaps unique, in Russia. Notwithstanding the enormous mass of water that it carries at the time of the melting of the snow, and the immense cakes of ice that float upon it toward the Arctic Ocean, and notwithstanding the terrible shocks of these floating cakes, its banks remain exempt from all damage. When the waters retire again to their bed the banks of the river are found just as they were before the inundation. This is evidently due to the fact that the banks are covered with species of trees having strong and somewhat spreading roots. When civilization arrives and denudes the soil, things will change their appearance.

It now remains for me to give a few details as to the work of opening up the places of this part of Siberia.

Up to the present day the miners had searched for auriferous deposits by digging pits in the soil, and which soon became filled with water, and impracticable. On my arrival, I introduced into the exploitations the method of boring, which is much more economical and much quicker. I likewise taught the miners how to use dynamite for blasting and for breaking up rocks. They had, up to that time, employed blasting powder for the purpose, and I had no little trouble in persuading them to abandon this routine process. I also succeeded in causing them to adopt a few other new methods.

The exploitation of the gold mines is sometimes performed in open air, and sometimes in galleries. The auriferous deposits in the beds of old water courses are sometimes located at such a depth that it would be impossible to remove the whole incumbent mass of earth in order to work them. The reader will obtain an idea of the general appearances of the gold mining operations by consulting the accompanying engraving, which represents the mine of the Menschikoff-Bazanoff-Siberiakoff Company. The earth containing gold is carried in carts to the place where the mining operations are prosecuted, and is there thrown into a cylinder pierced with holes. This, in revolving, divides the mass, and pours the earth out on to an inclined plane in the form of a stairway, each step of which retains the more heavy sand, which is the portion containing the gold. This sand is afterward washed by hand by the laborers, and then the gold is weighed, stamped, and entered on the official registers, and carried to the laboratory of Irkoutsk, where it is cast into ingots. From thence it is transported by a caravan each year to St. Petersburg. It is only then that the proprietors of the mines receive the part of the precious metal belonging to them; for, in Russia, the exploitation of gold is a government monopoly. The proprietor of a mine is not permitted to appropriate the least speck of gold found on his land without special permission of the chief of the imperial section of mines. It is difficult to conceive of the richness of the gold mines of Eastern Siberia. Each year there are discovered new placers or alluviums containing gold dust. I am positive that a large number of valleys contain auriferous deposits of exceptional richness, but which cannot be worked because of the want of the resources necessary to life and the need of means of exploitation. It is especially during summer that the workmen and condemned persons are employed at out-of-door work, but in winter they are set to work in the subterranean galleries. The horses used in the mining operations are brought from Tomsk, since the Iakoute animals are not strong enough to endure labor of this kind.

It must not be forgotten that at the mines a *poud* (about 16 kilogrammes) of hay costs 10 to 15 francs. And so it is with everything, especially with European products. This permits me to assert that Nordenskiold's expedition had its *raison d'etre* and its practical side. For, in proving that there exists in the glacial ocean a practicable route between Europe and the Lena, it opened up Eastern Siberia to European commerce; and the fruits of this bold enterprise may prove immense.



1.—The Courier. 2.—Working a Surface Gold Mine. 3.—Types of Miners. 4.—Gold-Washing Machine.

THE GOLD MINES OF SIBERIA.

ELECTRICITY A PRECAUTION AGAINST FIRE.*

By DR. WERNER SIEMENS.

THE lecture commenced by Dr. Siemens, in speaking of the Vienna disaster, calling the attention of his hearers to the fact that, since the general introduction of illuminating gas during the past few decades, the extensive use of petroleum at the present time, the general employment of readily inflammable fabrics, and other similar materials, the use of friction matches, etc., the danger of conflagration, notwithstanding the increased use of fireproof materials in construction, has undoubtedly increased. The losses by fire have been diminished rather than increased; still, this is attributed to the greater experience which has been acquired in the continuous battle against fire. The many improvements which modern science has brought about for the purpose of preventing the spread of conflagrations have had considerable influence toward this end. In 1852, Dr. Siemens said, a system of fire telegraphs was introduced in Berlin. It consisted of a series of underground wires, which were spread over the entire city and connected the fire depots with the police stations. By this means it was possible, in case of a conflagration, to call together the entire fire department. The construction of numerous simple indicators, capable of being operated by any one, which, when used, would automatically inform the fire department of the number of the indicator, seemed to be the most effective means of preventing large fires. These were not only placed in the most important thoroughfares, but also in the most important and readily combustible buildings. In large public buildings, factories, theaters, and the like, it is particularly advisable to have special arrangements by means of which it is possible to locate the position of the fire in the building itself, so that one can immediately concentrate the attention on the spot where the fire originates, without being obliged to hunt it up. Toward the numerous apparatus devised for the purpose of calling the fire department, for dropping an iron curtain in the theatres, for manipulating reservoirs of water, for opening ventilators in order to permit the escape of smoke, Dr. Siemens was not favorably inclined, for the reason that all such devices were apt to be found ineffective just when they were about to be used. Signals were generally given just too late, for the fire must spread to a certain extent before the action of the apparatus takes place.

The transmission of power, however, might be utilized in such cases, as it can be used for operating the means of safety, when these are distributed at certain points in the building. The introduction of electrical illumination in theaters was especially commended by the speaker. There can be no danger from the employment of the electric light. The tension in electrical illumination amounts to but a few hundred volts, and even with a tension of one thousand volts, it would be impossible to produce a measurable spark, and hence the passing of a spark between two wires or with other objects, is impossible. The newspaper criticisms in opposition to this are not borne out by the facts. The dangers of the electric current to life and health have, likewise, been greatly exaggerated. An electric illumination, which has been carefully and scientifically made, will produce no danger from fire, nor is it injurious to life and health. As being specially adapted to the illumination of theaters, the lecturer recommended the incandescent lights. These have the special advantage for the stage of not giving a white or more like a faintly yellow light, like the electric arcs, but a reddish light, similar to that of gas light. The different forms of such incandescent lamps were then practically shown by a series of Chanzy, Edison, Swan, and Siemens lamps.

In conclusion the lecturer expressed the hope that the largest possible extension of electro-technic knowledge would take place, and that chairs of electro-technics would be introduced in the leading universities.—*Zeitung des Vereins der Deutschen Eisenbahn Verwaltungen*, vol. xxii., p. 2, 1882.

* A lecture before the Electro-Technic Society of Berlin.

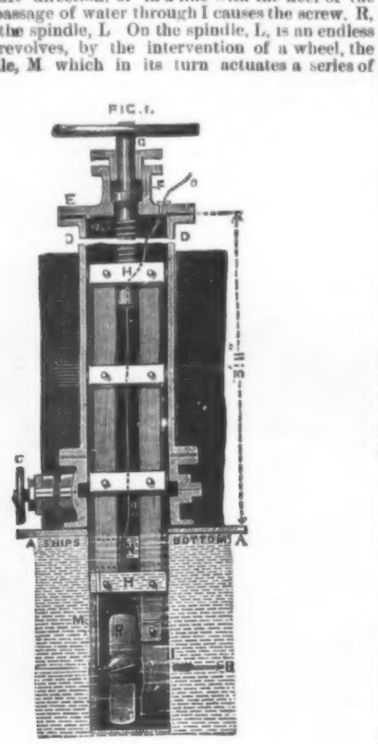
DETECTION OF ADULTERATIONS IN ASPHALT.

THE following method is recommended by D. Claye: The solution of the mass in carbon disulphide is, after filtration, evaporated to dryness and heated until it can be ground to a powder in a mortar. One-tenth of a gramme of the substance thus obtained is treated with five cubic centimeters of fuming sulphuric acid for twenty-four hours. It is then mixed with ten cubic centimeters of water with continuous stirring. Pure asphalt may be recognized by the colorless or light yellow solution that is obtained, while when pitch, coal tar, etc., are present, the solution is of a dark brown or blackish color.—*Geo. Bl. Wurtemb.*, 33, 509.

THE ELECTRIC LOG.

THE accompanying engravings illustrate an electric log for registering the velocity of solids moving in water, or the velocity of water currents, to which we have previously referred. In Fig. 1, the line, A A, denotes the bottom of the vessel, traveling in the direction shown by the arrow, B. C is a sluice valve, bolted to the bottom of the vessel, shown open, and allowing the sea full access to the iron box, D. The iron box, D, is bolted to the upper flange of the valve, C, and is closed at its top by the metal plate, E, which effectually prevents the ingress of water to the ship's hold. Through the stuffing-box, F, in plate, E, passes the metal rod, G, the screw thread on which raises or lowers the metal cage, H. To the bottom of the cage, H, is affixed the cylinder, I, having its opening for the passage of water in a fore-and-aft direction, or in a line with the keel of the vessel. The passage of water through I causes the screw, R, to rotate with the spindle, L. On the spindle, L, is an endless screw, which revolves, by the intervention of a wheel, the vertical spindle, M, which in its turn actuates a series of

FIG. I.



wheels in the box, N. The last of these wheels, termed the "mile" wheel, makes one revolution while the vessel passes through the water one nautical mile. On the spindle of this "mile" wheel is affixed a second wheel, having eight ratchet teeth; and these teeth, by moving a lever, cause an electric circuit to be completed—obviously eight times in a mile—the current passing through the electric cable, O, to the indicating dials and bells. On the dial, Fig. 2, there are eighty graduations on the outside circle, and as the pointer in front of the dial jumps one graduation at each completion of the electric circuit, one revolution of the larger pointer represents ten miles. Ten revolutions of this pointer cause the smaller one to make one revolution, recording 100 miles—the mechanism of this dial being similar to a gas meter index. The bell is placed within an audible distance of the officer on watch. The log is made by Messrs. Kelway

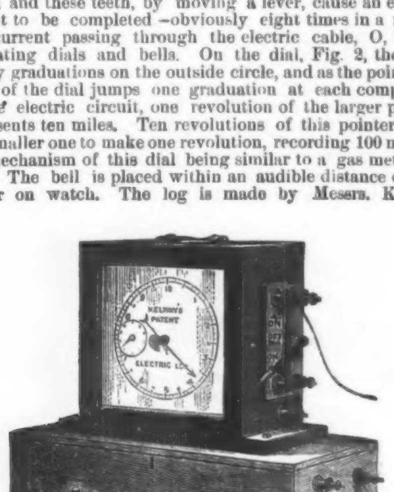


FIG. 2.

& Dyer, 29 New Bridge street, and is now at the Crystal Palace International Electrical Exhibition, between the Chinese Court and Pompeian House.—*The Engineer.*

CRYSTAL PALACE ELECTRICAL EXHIBITION.

A VISIT to the electrical exhibition now open at the Crystal Palace can now be made with every prospect of seeing the principal electrical lights in operation. The visitor should commence systematically, comparing, when possible, arc lights with arc lights, incandescent with incandescent, and so on. He must not think of getting a full and complete knowledge of details. Externals alone are within his view. The cost must be taken as stated by the exhibitors, or as published by the technical press. Starting then at the north end, the tropical courts are illuminated by the Lane-Fox incandescent lamp and the Brush arc lamp. Coming southward we notice the beautiful Weston arc lamps of the Electric Light and Power Generator Company, which also shows congeries of Maxim incandescent lamps. Then follows the British Electric Light Company, with the Brockie lamp; while the central transept and stage are lighted by the Crompton lights, and the orchestra with the Pilsen lamp. Above the crystal fountain hangs a fine chandelier, carrying Siemens lamps. Before coming to these, however, we notice the Mackenzie lamp. The André, Jablochkoff, and other lamps will be seen in due course.

The centers of attraction outside of the transepts will be the Picture Gallery, illuminated by Swan lamps, and the Concert and Entertainment Courts, illuminated by Edison lamps. We shall deal hereafter with the systems above-mentioned, as well as others which may have escaped this rapid review. Meanwhile we may call special attention to an accessory of the electric light, as it will show that, should Mr. Mattieu Williams be mistaken as to its future, the industrial branches dependent on gas may expect further developments, requiring a variety of designs and good workmanship. We refer to a chandelier especially designed and made by Messrs. Verity & Sons, of King Street, Covent Garden, for Mr. E. H. Johnson, of the Edison Light Company. This is placed in the Entertainment Court. It presents a huge basket of flowers, and is made wholly of hammered brass. Its height is 15 ft., while it measures 9 ft. across. The flowers represented—of which there are about 350—are the large sunflower, the narcissus, the tiger lily, the orchid, etc., down to the small clove pink.

ELECTRIC CHANDELIER AT THE CRYSTAL PALACE EXHIBITION.

Edison lamps are placed within the cups of the flowers. There are ninety-nine such lamps in three circuits, and when lighted, the light of the lamps and the blending colors of the glass cups are effective. The brass representing the stems of the flowers is of course hollow, and the thousands of pieces are so arranged that comparatively little difficulty was encountered in wiring the lamps. Our illustration has been engraved from a free-hand drawing specially taken for us. The lamps in each circuit can be turned on or off as required.

If it be possible to interest the visitor to the Palace in aught except the lights, he will do well to study the improvements that are taking place in telephones. At a recent exhibition at the Bristol Hotel by the United Telephone Company, it was shown that a number of people could receive the some sounds on different instruments, and still more recently at the houses of Colonel Gourand and Major Flood Page it has been shown that conversation can be carried on over the line while at the same time the musical sounds of an organ or orchestra are being carried. This points to the fact that the telephone will take up a number of sounds at one and the same time. Under ordinary business conditions, however, this sensitiveness is troublesome, and hitherto each user of a telephone has been compelled to have a distinct wire for his work. The introduction of exchanges minimized the length of wire used, but we think the instrument of Messrs. Brown & Saunders shown by the Eastern Telegraph Company, 66 Old Broad Street, is certainly a decided advance in telephonic work. By its use one line can be used by a number of instruments, and this, too, without danger of any one but the right person overhearing the conversation; in other words, secrecy is maintained.

The instruments used are designed for twelve to be placed on the one line. It is suggested that the apparatus would be very useful in suburban districts, or wherever the work of the line was light, as well as in large factories, but we fancy that its utility will extend further than this, and that it will be found that no evil effects will arise from putting three or four instruments on most of the wires belonging to the larger exchanges. If this surmise is correct, then we have at once the means of diminishing considerably the dangers arising from the multiplication of so many wires.

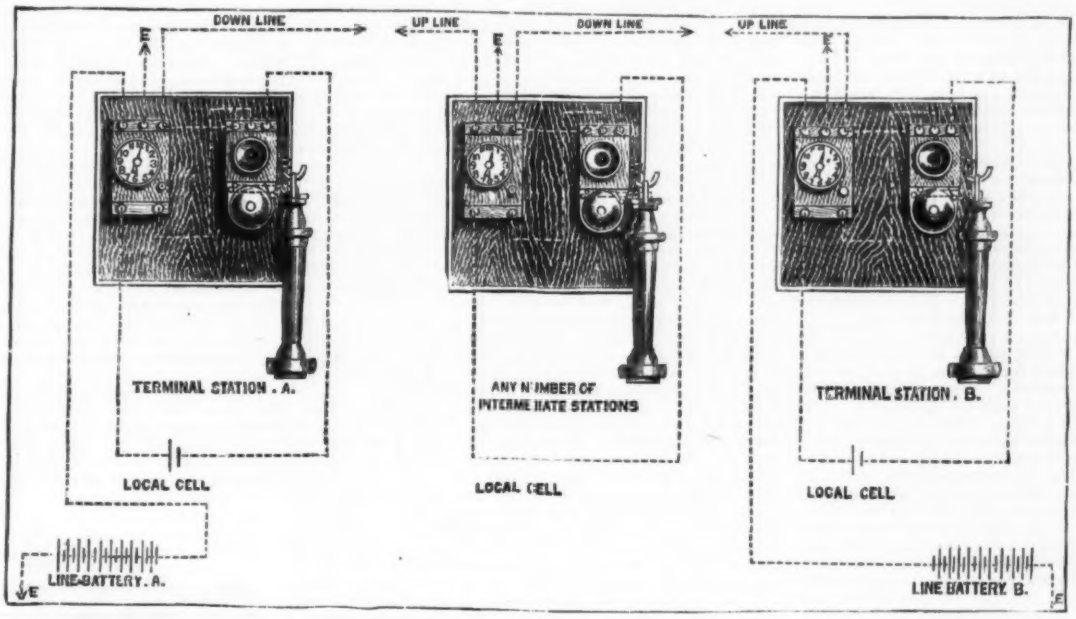
The apparatus is compact, and consists of a transmitter and receiver, with a bell and local battery. At the terminal stations the line batteries are placed to work in opposition, so that, except in the act of signaling, no work is required of them; hence they remain active for a long time. The signal instrument consists of a clockwork movement, A—Figs. 1 and 2—controlled by an electro-magnet, D, and actuating a main arbor or axle, C. This axle carries a hand, B, to indicate the numbers of the respective subscribers; also a slotted disk, H, and a cam, I. Metallically attached to the main framework is a ringing spring, K, which extends over the slotted disk, H, and under normal conditions makes contact with the spring, L, which is attached to the main framework by a piece of ebonite. Affixed also to the main framework by the same piece of ebonite is another spring, P, which rests on the top of spring, K, but is insulated from it by an ivory stud. This spring, P, when spring, K, is pressed falls upon and makes contact with a screw stud, *p*, screwed through the top of the main framework, but otherwise held out of contact therewith by spring, K. When the hand, B, comes round to the number or signal belonging to the station in which that particular instrument is placed, the cam, I, comes into contact with and slightly lifts the ends of the two springs, N and O, attached by a piece of ebonite to the main framework, as shown, and in so doing breaks the contact of N with a screw stud, with which it normally makes contact when not so lifed by the cam.

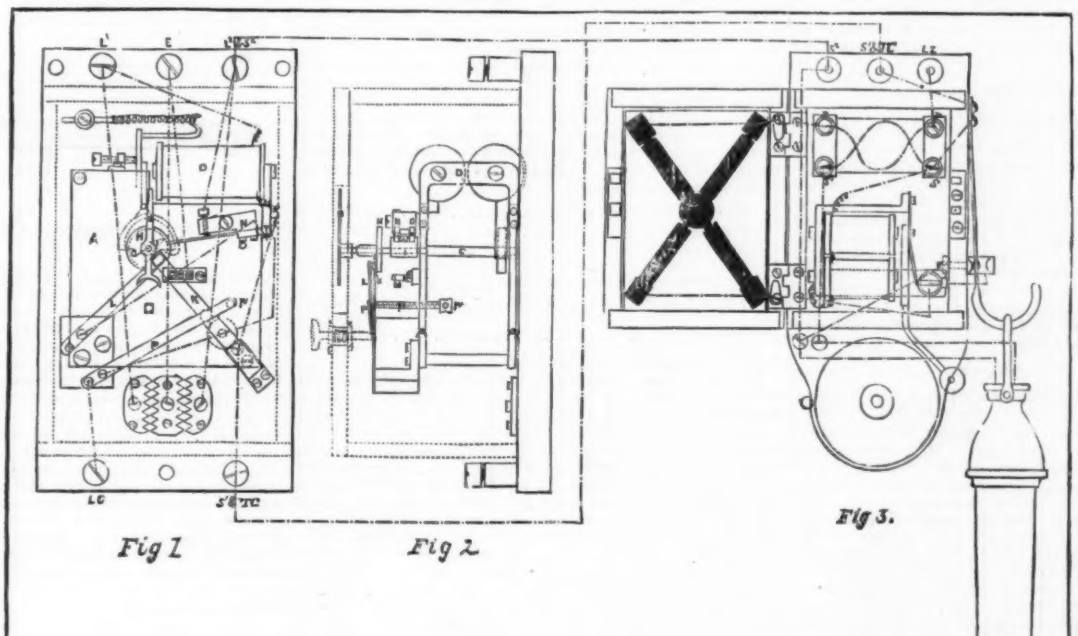
Two terminal and an intermediate stations are shown. The index shows the number of subscribers to stations on the circuit, and the position of the pointer indicates the station called. The call is made by a push like an electric bell push. The push causes the pointer to go forward one-half step; the release causes it to go forward another half step; and this action is continued till the number of the station required is reached, when attention is roused by the ringing of the bell. The action of the instruments will be understood if we state how the connections are made. At a central station the positive pole of the local battery is connected to terminal, L C, Fig. 1; the negative pole to L Z, Fig. 3; the terminal, E, is put to earth. One line—say, the up line—is connected to L¹, and the down line to L² S². The terminals, S² T C, are connected as shown. At the terminal stations, what we have called the up wire is connected to the zinc pole of the line battery, the copper pole being put to earth. The details, although they may seem complicated, are not so, but will be readily understood.

The connections are then as follows: A wire leads from the line 1, marked L₁, or upper left-hand terminal of the signal, looking at it from the front, to the electro-magnet, D, the other side of this coil being attached to the main framework. The current then goes by the terminal, marked telephone is hanging thereon, but this short circuit is, of course, broken when the telephone is taken off the hook. This completes the set of connections for the line circuit.

For the local circuit a wire is then run from the copper pole of the local cell or cells to the terminal, L C, being the lower left-hand terminal of the signal. From here a wire leads on to the lower cross spring, P, and also to the lower spring, O, of the pair of springs, N O. It will be seen that at both of these points local copper is capable of being put into contact with the main framework, either by hand—by pressing spring, K, and so dropping spring, P, on to its contact stud, *p*, in the frame—or automatically by bringing cam, I, into contact with spring, O.

The action of the apparatus is as follows: The hands standing at zero—indicating that the line is disengaged—any subscriber can call by pressing his ringing plunger. The spring, K, will then be pressed through the slot in the disk on to a stud, M, which is in electrical connection with the earth terminal, E, or upper central terminal of the signal—the slot in the disk, H, being then, and then only, in position to allow of this taking place. This puts an intermediate earth on the line, and so brings the opposed line batteries into effective action; the one battery working all the instruments on the one side of the caller, including his the switch bell transmitter along with the line current, with which, however, it makes no contact, in consequence of there being no connection whatever with the other pole of the local battery except by its own wire. From the top or center of motion of the switch hook, then, to which this terminal is connected, the local current goes on through the bell coils to the upper stud of the switch hook—or that stud with which the hook is in contact when the telephone is removed therefrom—so that when this is the case the bell is short circuited. From this point the current goes by the transmitter and primary coil of the induction coil to the terminal, L Z, being the right-hand terminal of the switch bell transmitter, from which a lead is run back to the zinc pole of the local bell or bells, thus completing the local circuit.—*The Engineer.*





THE BROWN & SAUNDERS TELEPHONE SYSTEM AT THE CRYSTAL PALACE EXHIBITION.

S² and T C, being the lower right-hand terminal, and the similarly lettered or center terminal on the switch bell transmitter, Fig. 3, to one side of the secondary coil of the induction coil, calling on its way at the top—or center of motion—of the switch hook as shown. From thence the current goes on through the secondary and telephone or telephones to the under stud of the switch-hook, or to that stud with which the hook makes contact when the telephone is hanging thereon, and thence on to the terminal, marked S², being the left-hand terminal of the switch bell transmitter, and thence on by the short external bridge wire between the two instruments to line.

There is thus always a complete circuit through the instrument for the current by the parts above named. The part of this circuit consisting of the telephone and secondary, however, is normally kept short circuited by two distinct methods, as follows: One of these shunt circuits starts from the clock frame by the spring, K, which is normally in contact with spring, L, and thence goes on to spring, N, which is normally in contact with its screw stud, from which a wire leads to the terminal marked line 2 or L², being the upper right-hand terminal of the signal, which is also the terminal to which the wire from the other end of the secondary and telephone is joined. The other short circuit is through the switch hook, as will be seen when the own instrument, and the other battery working all the instruments on the other side of the caller, the effect of the current being to draw up the armatures of all the electro-magnets, D, and so cause the clocks to advance one half step. By then letting the plunger come back, and so breaking the contact of spring, K, with the earth stud, M, the armatures will be again let go, and the clocks will advance another half step. By then alternately pressing and releasing the plunger, the subscriber can bring the hands round to the number he wants, and there stop. The cam, I, in the instrument belonging to that number will then be in contact with spring, O, thus ringing his bell, and will also, by breaking the contact of spring, N, with its contact stud, break the short circuit through the signal of the telephone and secondary, thus placing him in effective speaking condition. It is then his duty to answer by taking off his telephone and calling "Yes" through the transmitter, the act of taking off his telephone automatically removing the remaining short circuit thereof and at the same time short circuiting the bell, thereby stopping its sounding and concentrating the local current on to the transmitter.

The local current having been put on to the main framework will traverse the following circuit: First it passes out of the signal instrument by the terminal, S² and T C, and the outside connecting wire to the similarly lettered terminal on

A CHEAP FORM OF VOLTAIC BATTERY.*

By ALFRED R. BENNETT.

IN these days of dynamo and magneto electric machines and accumulators, voltaic batteries may seem old fashioned and out of place but they have, nevertheless, functions of their own, such as the supply of electricity for domestic purposes, for telegraphy and telephony, which possess sufficient importance to render any improvement or economy effected in their construction worthy of note. The author trusts that this consideration will be deemed a sufficient excuse for bringing before the Philosophical Society of Glasgow the details of a new and exceedingly cheap form of voltaic battery lately devised by him.

The object he had in view was to discover a combination capable of performing at less cost the duties at present so admirably fulfilled by the Leclanché battery. Although the new form has not yet undergone the crucial test of prolonged trial in actual service, yet for some months it has been subjected to severe tests side by side with the Leclanché, and has not shown any evidence of inferiority, either as regards power or durability.

The idea of the combination was suggested by the well known fact that iron will not rust in solutions of the caustic alkalies, a fact probably due to the non-existence in such solutions of free oxygen and free carbonic acid. It was argued from this that if a plate of iron and a plate of zinc were immersed in such a solution, the iron not being attackable by the alkali would be strongly electro-negative to the

* Extract from paper read before the Philosophical Society of Glasgow, on February 1.

zinc. Trial proved the idea to be strictly correct; not only iron, but nickel and cobalt, as well as gold and silver, and the metals of the platinum group, were found to be practically as electro-negative to zinc as carbon itself. Carbon is at first a little more strongly electro-negative than iron, but owing to the absorption of hydrogen in its pores as soon as the circuit is closed, it is in practice in no wise superior

Silver is the most electro negative of all the metals in these solutions. The use of iron, if practicable, has obviously several advantages. The cheapness of the metal and its freedom from liability to fracture as compared with carbon are strong points in its favor, and it affords besides the possibility of making a perfect and permanent connection on the negative plate for the binding screw, an end so difficult to attain when carbon is used. It was discovered, however, that a simple iron plate polarized very rapidly, the hydrogen set free by the action of the battery clinging to it and greatly increasing the resistance. By surrounding the plate with a packing of small fragments of iron, such as clean turnings or borings, in the same manner as the carbon plate in the original type of Leclanché, is surrounded by fragments of carbon and manganese dioxide, this deleterious action is considerably modified, and the cell acquires to a great extent the power of keeping up its electromotive force when working continuously through a low external resistance. The number of points presented by the turnings or borings is probably the cause of this, as it is well known that hydrogen escapes with much greater freedom from a rough than from a smooth surface. The packing of iron fragments is, in fact, the platinized silver plate of Smee in another form. The greatest efficiency is obtained when the iron fragments are thoroughly damped by the solution, but not immersed in it, the obstacles to the escape of the hydrogen being then at their minimum.

Although not quite constant when working through an external resistance of 20 ohms, the battery recovers its original electromotive force when allowed to rest with a rapidity sufficient to allow of its employment on the busiest telegraphic circuits and for most other practical purposes. The electromotive force of the iron battery varies somewhat with the nature of the iron and the purity of the exciting salt employed. Also with the degree to which the iron fragments are saturated or covered by the solution. The Daniell being 1, and the Leclanché at its best 1·30, the iron varies from 1·15 to 1·33. The last was an exceptionally good cell, and the average may be taken at 1·23, or 0·07 less than the best Leclanché. But after working for some days continuously through a low external resistance, the iron keeps up its electromotive force much better than the Leclanché. This was proved lately, at the suggestion of Mr. David Graham, who thought it likely to demonstrate the comparative capacities of the two batteries for actual work by setting a good specimen of each cell to ring an electro-magnetic trembling bell of precisely similar construction, and each of a resistance of 5 ohms, day and night, until they failed. They were started at 11·10 A.M. on December 23 last. After four or five days the Leclanché became very weak, and although it did not actually stop until January 12, it latterly simply vibrated the hammer of the bell without striking the gong. The iron cell rang the bell powerfully until January 15, and did not stop until January 23, exactly one month, or 744 hours, from the date of starting.

The chemical reaction of the iron battery is probably as follows: there being present when a solution of potassium hydroxide is used,

$$Zn_2+KHO+H_2O+Fe,$$

the closing of the circuit produces first,

$$2ZnO+K+H_3+Fe.$$

That is to say, at the positive plate the oxygen of the potassium hydroxide and of the water is given off, and combines with two atoms of zinc to form zinc oxide. At the negative plate, the potassium and the hydrogen of the potassium hydroxide, and the hydrogen of the water are set free. The metallic potassium instantly decomposes an additional molecule of water in the negative portion of the cell, with the oxygen of which and with one of the free atoms of hydrogen it combines to reform potassium hydroxide, leaving the four atoms of hydrogen due to the decomposition of water free. This makes the final stage,

$$2ZnO+KHO+H_4+Fe.$$

The caustic solution is consequently used up in the positive half of the battery and reformed in the negative. It is to the polarizing action of the free hydrogen that the inconstancy of the electromotive force is due. It, however, as has already been stated, ascends between the iron fragments and rapidly escapes to the air. The author has attempted in many different ways to get rid of this obnoxious gas, but without permanent success. Mixing platinum black with the iron packing answers to some extent for a time, as the platinum absorbs the gas and leaves the iron free. Another plan is to place a chemical having a great affinity for oxygen, such as pyrogallic acid, nitrate of cobalt, permanganate of potassium or sodium at the negative plate. But the chemicals which absorb oxygen with sufficient avidity have little permanency and soon cease to act. The presence of a permanganate raises the electromotive force of the battery in addition to improving its constancy, but the effect is transient. A cell was placed in a jar of oxygen in hopes that this gas would find its way through the iron packing and combine with the hydrogen to form water. But the hydrogen would have nothing to say to the oxygen until it was clear of the battery. It then combined, and the cell being kept at work was, in a couple of weeks, drowned in water of its own creating. These are, however, at best complications which, besides being superfluous, are inadmissible on the score of expense in a cheap battery, which the one under consideration is specially designed to be. Its cheapness and the ease with which it can be made up are, indeed, its most remarkable features. There is here an old tinned iron can, which, as the legend upon it distinctly states, was originally packed with corned beef in Chicago. At that time there was little probability, it is to be presumed, of its making its appearance before such a learned assembly as the present. The beef having been consumed in Glasgow by some of Her Majesty's lieges, now unknown, the can was cast aside as useless, and was acquired without much difficult or prolonged negotiation by the firm of Messrs. D. & G. Graham for the sum of one farthing sterling. There is also here a quantity of iron borings swept from the floor of an engineer's workshop, the cost being simply the time and trouble consumed in sweeping. There is also a strip of common zinc, cut from an old roof ventilator, a porous cell, and a bottle containing a solution of 4 oz. of commercial potassium hydroxide. The porous cell being placed in the tinned iron can and packed with borings, the solution is poured in, and the zinc strip immersed in it.

The tendency of the caustic alkalies to absorb carbonic acid from the air renders it desirable, although not absolutely necessary, to keep the porous cell which contains the solution tightly covered. On the other hand, the iron portion of the battery should be exposed as freely to the air as possible, to facilitate the escape of the hydrogen. These contrary conditions are rather vexatious, but by no means impossible of attainment. The most practicable mode of solving the difficulty appears to be the placing of the positive portion of the combination in an earthenware cell about 7 inches in height, but porous only for 4 inches from its bottom, which porous cell is fitted with an air-tight stopper, through which the zinc rod is brought and terminated by a binding screw. The earthenware cell is placed in an iron can 5 inches in height and of a like diameter, and packed in firmly with turnings or borings. The earthenware cell, having been filled with solution almost to overflowing, the air-tight stopper is fitted in, and the battery is ready for use. The advantages of this arrangement are the exclusion of carbonic acid from the caustic solution, while the iron is left exposed to the air; the prevention of evaporation, and the preservation of the packing from too profuse a wetting. There being no air pressure on the surface of the solution in the earthenware cell it can only percolate with extreme slowness, being opposed by the pressure of the air acting through the iron borings and the pores of the cell. The presence of carbonic acid in ordinary water renders it desirable to make the solution with distilled or newly-boiled water. If this is done, and the cell instantly closed with an air-tight stopper, the conditions necessary to secure the best results have been complied with. Instead of distilled or boiled, common water may be used if a portion of newly-slaked lime is added to the solution before closing the cell. For ordinary purposes, however, these precautions may be dispensed with.

Now, as to the cost: the tinned iron can may be used without detriment. The tin, being strongly electro-positive to iron, sets up a local action with the borings as soon as the solution reaches it, and, being small in quantity, is soon resolved into tin oxide without injury to the battery. The soldered joints of American preserve cans are but very little affected by the solution, and can be depended upon not to leak if tight in the first instance. Solders in which tin or zinc are present ought to be attacked, but copper and lead are but little acted upon. The joints of such cans are probably so carefully made in the first instance as to be mostly water-tight without the aid of solder. These cans may therefore be regarded as perfectly efficient although so ridiculously cheap. The cost of one, including the borings, which are by no means scarce in Glasgow, may safely be put down at one farthing. The borings never need renewal, as they do not rust and are not changed in any way by the action of the battery. The zinc may be of the commonest kind, as no local action of importance has been observed unless the caustic used is very impure. Amalgamation is therefore useless. Strips of common roofing zinc rolled into cylinders answer perfectly well. The porous cell is the most expensive item, but this can be dispensed with by the use of diaphragms of canvas or other fabric of vegetable origin. It must be remembered that the caustic alkalies destroy all animal tissues, so leather, bladders, etc., are not admissible. The author has tried cells of thin wood, such as willow boxes, with success; but the earthenware is more permanent, and, in spite of its prime cost, probably the most satisfactory in the end. Such as the one before you can be procured wholesale at 2d. each. A diaphragm of some kind is absolutely necessary. Caustic soda, in a state of reasonable purity, is made in the neighborhood of Glasgow, and can be obtained wholesale at a little over 1d. per lb. Whether this is sufficiently pure for long continued action has, however, yet to be determined. To sum up the cost of one cell in its simplest form, we have:

Can and borings	¼d.
Porous cell	2
Zinc, say	1
Soda, 4 oz.	½
Soldered wires for connections	1
Labor	1¼
Total	6d.

which is quite a liberal allowance.

The battery is, consequently, probably the cheapest ever devised in proportion to its power and durability, when regarded in the light of prime cost, but it becomes even cheaper when it is considered that the chief product of its action is zinc oxide, known in the paint trade as zinc white, which is extensively used as a pigment, and as a substitute for white lead generally. It can easily be recovered in an approximately pure state from the used-up battery. From the cell which rang the bell for a month 1,458 grains, or 3·04 oz. troy, were recovered, the zinc consumed being 1170·7 grains, or 2·44 oz. troy. Some of it—one-sixth of the quantity recovered—is on the table before you. Its price in the market ranges from 6d. to 1s. 6d. per lb., according to purity. As this is by no means a bad example, containing only a very slight trace of iron, its value exceeds that of the zinc consumed. It has been said that voltaic batteries can never compete with dynamo machines, because the zinc used takes coal to reduce it from its ores to the metallic state, which coal would have produced the energy direct if burned in the furnace of a steam-engine driving a dynamo. But if the product of the consumption of zinc in a voltaic battery can be made to defray the cost of the zinc, that oft-quoted argument somewhat loses its force. However that may be, it is pretty evident that the man who can buy, borrow, or ——— otherwise become possessed of a few old preserve cans, a corresponding number of porous cells, a quantity of iron borings, with a few pounds of caustic potash or soda, and who has an old zinc chimney to cut up, can conjure up and render subservient to his wants or his pleasure in many ways that mysterious but beneficent force which we know as electricity. He may, perhaps, even light his library on a small scale, or drive his wife's sewing-machine; and, after all, when the battery ceases to work, he can take it to pieces and paint his house, or a part of it, with the products.

The battery, however, need not be made cheaply. It lends itself with equal facility to the taste of the sybarite as to the means of the working man. As before stated, nickel, cobalt, silver, gold, platinum, are all strongly electro-negative to zinc in caustic alkalies, and might all be used to good purpose. A golden goblet packed with half sovereigns, instead of a tinned can packed with iron borings, would ring an electric bell or work a telephone admirably; as would also a silver chalice packed with sixpences. So it is obvious that refinement is possible in voltaic batteries, as in everything else. It may be noted that copper also answers well instead of iron for a time, but a soluble salt of copper is gradually formed, which is precipitated upon and stops the action of the zinc. On the table are various forms of the battery. In some, the negative plate, consisting of an old file, an old knife, or a spiral of iron wire, is packed with the borings in a porous cell, the positive portion of the battery in such cases being in a glass or earthenware jar.

MERCADIER'S SELENIUM PILE.

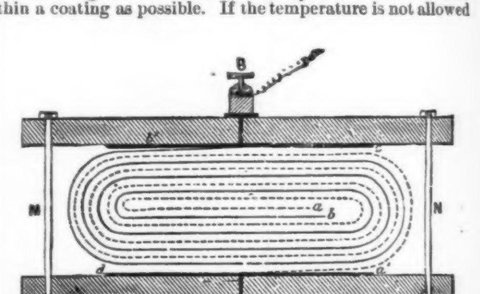
In speaking of the teleradiophone we have incidentally mentioned the selenium element employed by Mr. Mercadier in this apparatus, without our having made its peculiar arrangements known.

This small system is analogous in principle and design to the selenium element employed by Mr. Graham Bell in his photophone, it being an apparatus of variable resistance, under the influence of a luminous ray of more or less intensity, that falls on it. It differs therefrom, however, in certain points—its construction being much simpler and easier. It therefore deserves a description, since it may be applied equally well in all radiophonic researches.

The accompanying cut represents one of the selenium elements, actual size, which has been constructed in this form by Messrs. Mercadier & Humblot, so as to be afforded at small expense, and that it may be quickly put in good order again if it should deteriorate. In the construction of this element there are used two brass ribbons, *a* and *b*, of about a tenth of a millimeter in thickness, and of a centimeter in width. These are separated by two ribbons of parchment paper serving as an insulator, and the four ribbons are then rolled in spiral form as shown in the figure, where one of the brass ribbons is represented by a continuous line, the other by a broken line, and the paper by the blank interval separating them.

The block thus formed is held between two brass plates, *c* and *d*, which are in contact, respectively, with the extremities, *a'* and *b'*, of the metallic ribbons. The whole is tightly compressed between two blocks of hard wood held together by two cross-pieces, M and N. The element is connected with the circuit in which it is interposed, by means of two terminals, A and B, which are in metallic communication with the plates, *c* and *d*. One of the faces is then filed and afterwards carefully polished with emery paper. This done, and the perceptible absence of metallic communications having been ascertained by means of a galvanometer, the polished surface is covered with selenium in the following manner:

The apparatus is heated in a sand bath, or by laying it flat on a thick plate of copper heated by the flame of a Bunsen burner until the exact moment that a selenium crayon lying upon it begins to melt. Then the crayon is drawn along the surface in such a way as to cover it with as thin a coating as possible. If the temperature is not allowed



MERCADIER'S SELENIUM PILE.

to rise above this point the selenium takes the slaty tint which characterizes the state in which it is most sensitive to light. It is useless to heat it again, and, on allowing the apparatus to become cool it is ready to operate. In order to preserve the surface, it may be protected by a thin sheet of mica or covered with a layer of lac varnish laid on hot. If the apparatus happens to deteriorate, it is only necessary to file the surface again, repolish it, and add another coating of selenium, to put it in good order. The resistances of the elements vary greatly with the dimensions, the nature of the selenium, the mode of preparation, etc.

Constructed as we have described, the selenium receiver is adapted to all radiophonic and photophonic apparatus, as well as to the numerous experiments by means of which are demonstrated the singular electric properties of this body at present so little known. To obtain good results there are required about ten Leclanché elements mounted for tension, and very resistant telephones, that is to say, such as those whose very fine wire is wound a great many times around the magnetized core.

A NEW AND DELICATE TEST PAPER FOR AMMONIA WHEN IT IS IN THE FORM OF A GAS.

By GUSTAV KROUPA.

When fuchsine is dissolved in water and dilute sulphuric acid added, its red color will be changed to a yellowish brown (the mono acid becomes converted into the di or tri sulphate). If stripes of unsized paper be dipped in a not too dilute solution of rosaniline and dried, they will appear—similar to turmeric—of a beautiful yellowish color.

Paper prepared in the above-described manner is permanently colored carmine by ammonia when it is in the form of a vapor. The action of the ammonia is to convert the poly-acid—rosaniline into a monacid fuchsine. This paper is of use for the detection of ammonium salts when they are present in small quantities. The substance to be tested is placed in a bottle and moistened with calcium hydrate. The bottle is closed with a piece of the test attached to the lower part of the stopper. It is best to employ the paper when it is in a dry state, because when it is moistened it becomes bluish and its change to red is not so readily perceptible. In order to hasten the decomposition of the ammonium salts, the bottle with its contents may be warmed, as the paper is not affected by steam. By this means a beautiful red color may be produced with 0·0005 gramme ammonium chloride, and 0·0005 gramme ammonium carbonate in a very short while. When it is exposed to the air it is liable to be attacked by moisture, though only after some time; it is therefore best to preserve it in well closed vessels. It cannot, however, be kept indefinitely, as it is too fragile, whereupon it is best to prepare a fresh supply.—*Chemiker Zeitung*, v. 952.

ON THE DETECTION AND SEPARATION OF SILICA, ALUMINA, GLUCINA, BORIC ACID, THE ALKALIES, AND SOME OF THE METALS, BY THE MICROSCOPE.

By H. REINSCH.

THE application of the microscope to the chemical examination of minerals and chemical compounds is daily increasing, and, in fact, is fast approaching the spectroscope for the detection of minute traces of various oxides. In reality it surpasses this latter instrument, in that it gives results which can be measured, even though the quantity present is infinitely small. Still, microscopic investigation requires considerable skill, and in order to avoid mistakes, it is essential that the investigator should prepare test objects in order to verify his results, for as yet these cannot be purchased.

It is of special importance in making observations to obtain the proper dilution of the solutions, for according as the degree of concentration of the solution of a salt, so does it vary in appearance; and therefore it may happen that different reactions will be obtained from one and the same salt, as is shown in the following examples:

First, we prepare a four per cent. solution of the salt to be investigated with distilled water, and dilute this to a two per cent. and a one per cent. solution. By means of a glass rod, three drops of each of these three solutions are brought on to the slide, which is to be used in the experiment in such a way that one has one large and two small drops of each. These are allowed to evaporate, and they are then examined under a microscope (which is furnished with a polarizing apparatus), in the light field of vision, *i. e.*, beginning at 0° and turning the Nicol prism, and then again at 40°, 60°, and 90°, until a gradually darkened field of vision is obtained.

Those tests which agree in form and relations of polarization are retained as test samples. Silica, of all substances, yields the most varied and beautiful forms, resembling plants and ferns, often presenting, in the most glowing colors, five-leaved flower forms in infinite varieties. To obtain these forms, we place a drop of a four per cent. solution of potassium silicate on an object slide, and then add a drop of a two per cent. solution of sodium bicarbonate, and then allow the liquid to evaporate at the ordinary temperature; after a few hours have elapsed the most beautiful flower forms will be found spread over the slide, and will be readily recognized by a pocket lense, but when examined by the microscope with the Nicol at 90°, will exhibit the crystals gleaming with a most magnificent play of colors.

By moistening the object with a drop of copal varnish, and covering it with a thin glass, these forms may be permanently preserved. If we mix a drop of the four per cent. solution of the silica solution with a drop of the one per cent. sodium bicarbonate solution, we fail to obtain any plant forms, but find polarized spheres, which, when the Nicol prism is at 90°, exhibit a dark cross, just such as are obtained with calcspar; on further turning of the prism it seemed to revolve visibly, and at 0° almost entirely disappears or passes over into a green cross.

The most minute traces of silica can, by this means, be readily detected in a mineral, by melting a small sample of the substance with a little potassium hydrate and dissolving it in a little water, and then placing a clear drop of the solution on an object slide in the manner previously indicated.

It is just as easy to microscopically determine aluminum oxide as it was to detect the silica. It may be recognized as well from its sulphates as from its alkali solutions. If we place a drop of a four per cent. solution on an object slide and allow it to evaporate, spherical crystals will be obtained, which, turning at 90°, show a white cross formed of pencils of rays; if we cover the object with a mica plate, and place the Nicol at 0°, the rays of the little spheres appear as if composed of a number of small black grains; placing it at 60°, they appear as two blue rays opposite to each other, which at 90° assume a corresponding position, and on further turning of the prism disappear entirely. If we mix a saturated aluminum oxide solution in potassium hydrate with sufficient water to produce a two per cent. solution, and place a drop or two of it on the slide, then mix the sample with a drop of a one per cent. solution of sodium bicarbonate, after evaporation, there will remain a dull white spot, which when still moist shows peculiar spheres; by means of these alumina can easily and positively be distinguished from silica; for they appear when the prism is at 90° as a white cross whose diagonal axis ends in two round or rhombic scales. If we mix the alkali solution of silica and aluminum oxide with a drop of sodium bicarbonate solution, the silica will appear as silvery, partly closed dendrites, while the alumina assumes lengthy forms which, when covered with a mica plate, seems blue, while the dendrites of silica are seldom colored.

Glucina may be very easily distinguished microscopically from both of the preceding earths. A drop of a four per cent. solution of glucinum sulphate when evaporated on the slide leaves large stars, which may be detected by the naked eye; whose fern-like leaves spread themselves over the entire surface of the drop. The star in the center, when the prism is at 90°, exhibits prismatic colors, the leaves appear of a dull silver white or brownish color, and they are often perforated.

The forms of glucina are so characteristic in their appearance that they cannot be mistaken for any other substance; however, the alumina may be hidden by it while the forms of silica remain unaffected.

Boric acid is likewise very easy to detect, for from its two per cent. aqueous solutions there is obtained, after evaporation, a series of very small plates hardly 2 mm. in diameter, which, when they are magnified 80 times, do not show any cross. If the residue of the boric acid be moistened with a drop of the two per cent. solution of sodium bicarbonate, the dried drop will be found to consist of beautiful polarizing spheres, which in their center inclose a small white cross; this on turning the Nicol prism also revolves. Occasionally dendritic stars instead of the spheres are formed. These have a cross or a dark hexagon at their center, and are apt to remind one of the silica reaction, but the difference is soon apparent when they are compared with the test sample prepared from silica. The alkalies possess such optic properties that they can be definitely and certainly distinguished by the microscope. In making these tests it is best to employ the sulphates for the examination, as they are the most constant in their composition, and in the drying the samples will not absorb moisture from the air and so produce forms which may readily be recognized. Four per cent. solutions were made of the alkalies soluble in water. The test with potassium sulphate gives, at 0° of the Nicol, a series of rhombic plates, which are not very well defined; at 90° blue rims with yellow or red spots are developed; these cannot be taken for any other alkali. Sodium sulphate will be recognized just so soon as it becomes dry by its decrepitation. In the darker field of the microscope it appears dull, and silvery-white in hopper-shaped quadratic crystals.

A mixture of both salts presents some remarkable optical characteristics, which show the formation of peculiar double salts, which can only be recognized optically. Their appearance readily recalls the behavior of the dextro and lævo-racemic acid salts. In the optical examination of the ash of a single cigar the lithia which is present in very minute quantities can be detected with great certainty. A neutral solution of the ash in dilute sulphuric acid, a drop of which is mixed with one drop of the one per cent. solution of the sodium bicarbonate, exhibits the peculiar perfectly complete spheres which are characteristic of the calcium carbonate cross. This reaction was altogether inexplicable to us, for it was impossible to produce it by any of the known elements of the tobacco ash. All attempts to prepare the spheres artificially from the known constituents of the tobacco ash were unsuccessful, but they were readily obtained when a larger quantity of the cigar ash was submitted to the same treatment. From the ordinary analytical methods no other salt than those known to be present in the tobacco ash could be detected. After mixing a four per cent. solution of potassium sulphate with a two per cent. solution of sodium sulphate and evaporating a drop of this mixture to dryness, neither the potassium nor the sodium sulphate was discernible; but the spheres which showed the calcium carbonate cross perfectly were easily recognized, and at the rim of the drop might be seen a series of crystals which likewise distinctly manifested the cross phenomenon; hence a double salt is formed, which has properties totally different from those possessed by either salt. It is remarkable that when the Nicol is at 0°, each of the spheres appears to be composed of two portions which are either connected by a seam or separated by deep furrows. Attempts to prepare these double salts in larger quantities than drops were unsuccessful, for on crystallizing the potassium sulphate separates out first, while the Glauber's salt remained in solution, the latter, however, retaining distinct traces of the double salt.

The ammonium sulphate assumes such peculiar shapes that it cannot be mistaken for any other salt. At 0° the crystals are hardly recognizable; at 90° they appear like partly decomposed walls built of gray blocks, with blue and brown rims.

Lithium sulphate forms clusters of prismatic needles which at 0° show beautiful colors and a blue cross, which at 90° becomes black. The most minute quantities of lithia can be recognized by their optical behavior.

Lime may be detected in several different ways: if a drop of a two per cent. solution of calcium chloride is mixed with a drop of a one per cent. sodium bicarbonate solution, the drop will become cloudy, and after drying it appears white and shows distinct dendritic stars which consist of an accumulation of small crystals. Barium and strontium salts fail to show this reaction, or only in a very indistinct manner.

Lime is best recognized under the microscope when it is in the form of the sulphate, and is prepared by mixing a drop of a soluble lime salt with a drop of sodium sulphate. The sulphate crystallizes in stellar shaped crystals, which can not readily be mistaken for any other forms. Barium and strontium are best detected when they are in the form of nitrates. Barium nitrate assumes mossy, glistening like silver, colorless dendritic forms; while strontium nitrate takes the form of radiating needles, which are bluish at 0°, and at 90° are blue, green, and red. Magnesia may, even when present in the most minute quantities, be detected by the microscope. If a piece of jurassic limestone, about the size of a pea, for instance, be moistened with a few drops of dilute sulphuric acid, diluted with water, and a few drops of the clear liquid placed on a slide, and then a drop of the one per cent. sodium bicarbonate solution added, the dried drop will show at their rim distinct silvery scales of magnesium carbonate. The sulphate forms colorless clusters of needles, which do not become colored even at 90°. Under certain conditions, polarizing spheres which are similar to those of alumina are obtained from magnesia, but they cannot be produced when desired, for they seem to be an accidental formation. Only the following of the heavy metals were microscopically examined, but in each case it appeared possible to detect them with great accuracy. Certain of them, however, like zinc, nickel, and cobalt, present similar results; so that great care must be taken not to mistake the results. Their tests, obtained with four per cent. solutions of the sulphates, yield dull, silvery quadratic prisms. The zinc test consists of net-forming scales, which at 0° are partly invisible and partly blue, at 50° they are almost colorless, and at 90° show brown rims.

The cobalt test is light blue at 0° and 50°, while at 90° it shows an array of brighter colors. The cobalt is partly invisible and partly blue at 0°; it becomes brown with blue spots at 70°; while at 90° it assumes the form of colorless icicles or light-brown trellises. The copper sulphate takes the form of steplike prisms, which at 0° are almost colorless, becoming at 70° light blue with green stripes, and at 90° show brilliant colors. The four per cent. solution of manganese sulphate shows broad scales, silver white to gray in color, and which are partly serrated at 0°, as well as at 60° and 90°. If the sample is left by itself for several days, polarizing spheres will appear; these are so peculiar that the manganese can readily be recognized from them, especially as no other metal forms such spheres.

Cadmium presents the most characteristic formations of all the metals; a four per cent. solution of the sulphate produces large spheres containing ellipsoids, which radiate from the center and are marked by regular transverse depressions. This formation can be recognized without a Nicol's prism, and therefore it is not the result of the polarized light, but evidently depends upon the mechanical arrangement of the crystals. On using the Nicol the spheres show at 0° a beautiful blue or green cross, whose color zones increase with the turning of the prism until 90° is reached, when the most beautiful colors of the rainbow are manifested, while the ellipsoid becomes darker, better defined, and the transverse depressions are marked by dark spots.

These phenomena become still more characteristic when observed over a plate of mica. From more dilute solutions of the cadmium sulphate, it is possible to obtain the spheres, but the peculiar structure is not observed. If a two per cent. solution of iron sulphate be mixed with a one per cent. solution of sodium bicarbonate, the drop soon becomes cloudy and is covered with a gold lustrous film of the oxide; after drying the specimen shows no spheres, but if it is allowed to remain quiet for two days, small crystals of iron carbonate are formed; these show the phenomena of polarization distinctly, but in a very peculiar manner. Uranium sulphate assumes the most beautiful forms of all the metals; a four per cent solution is taken, and at least twelve hours are necessary to produce the desired formation. It can readily be recognized with a pocket lens, and resembles beautifully colored asters or corn-flowers. Less frequently it occurs in the form of envelopes with velvet blue narrow, and purple colored broad triangles, which may also be recognized without the Nicol, and therefore are not produced by polarized light but result from the mechanical arrangement of the crystals. The mercuric sulphate is difficultly soluble, but it can easily be brought into solution by the addition of a few drops of nitric acid. It forms figures similar in shape to a Maltese cross, of superimposed scales, which are very unstable. Silver may easily be determined, and in such a way that it is not easily mistaken for any other metal. A drop of a two per cent. solution of silver sulphate deposits bright points which may be detected with the naked eye; at 0° these appear as complete rhombic octahedrons, with the edges cut off; at 10° they glisten with the most beautiful play of colors, like the diamond; at times groups are formed which seem exactly like a set of diamond jewelry.

I am convinced that the foregoing experiments are of great interest, not alone to the chemist, from their value in the qualitative analysis of minerals, but also to the crystallographer, who will be greatly aided in his examinations, for with the microscope the different transformations of the crystal can be observed so perfectly.—*Berichte des Deutschen Chemischen Gesellschaft*, xiv., p. 23.

ELECTROLYTIC ESTIMATIONS AND SEPARATIONS.

By ALEX. CLASSEN.

THE following experiments,* performed with my assistant, Mr. O. Bauer, on the employment of the galvanic current for the quantitative estimation and separation of chemical bodies, show that the electrolytic method is capable of extensive employment. The execution of quantitative analyses by electrolysis becomes so simple and certain that even inexperienced analysts are able to obtain results which could hardly be expected from those long skilled in the manipulations of the ordinary gravimetric methods. In addition, it must be observed that, as the galvanic current performs a greater part of the work, much filtration is saved, and the quantitative determinations and separations are much more rapidly effected than by the gravimetric methods.

With reference to the separation of iron and manganese, it has been found that the process given before may be greatly simplified, thus: if, instead of separating the manganese as sulphide, as was previously described, it be converted into the peroxide with sodium hypochlorite, and estimated as trimanganotetroxide (Mn_3O_4). This may be accomplished by pouring off the supernatant liquid after the reduction of the iron, and boiling with sodium hydrate, in order to destroy the ammonium hydrocarbonate formed during the electrolysis, and then adding to the solution a few cubic centimeters of sodium hypochloride.†

The manganese peroxide rapidly settles to the bottom, and can be filtered immediately. The precipitate is best washed with hot water to which some ammonium nitrate has been added.

When the complete separation of the two metals has been effected, some of the manganese peroxide adheres to the positive electrode. In order to remove it, the electrode is placed in a dish and the peroxide dissolved in a little hydrochloric acid, supersaturated with sodium carbonate, and then the liquid is added to the main solution. The remainder of the process is conducted as has been previously described. Other experiments on the separation of iron and manganese have shown that the separation of iron can be hastened by using a mixture of the potassium oxalate and ammonium oxalate, instead of forming a double salt with the ammonium oxalate. In our experiments, we first convert the metals with a solution of potassium oxalate (1:3) into the soluble double salt of potassium, and then adding ammonium oxalate until the latter is equivalent to six or seven times the amount of the calculated oxides. It is best to begin the electrolytic decomposition with a distance of about three centimeters between the electrodes of the two Bunsen elements (large size), and then increasing the current by the insertion of one or two additional elements as soon as the manganese peroxide begins to separate. The rapidity with which the iron can be separated is shown by the fact that one gramme of metallic iron can be precipitated in one and a half hours. This fact is of particular value to the iron metallurgist, for it enables him to determine the amount of manganese in pig-iron within a very few hours time. By its use a whole series of determination can be made at the same time, and with great accuracy.

SEPARATION OF IRON, MANGANESE, AND PHOSPHORIC ACID.

By the ordinary methods, the separation of these bodies is effected in different solutions, and the phosphoric acid is estimated with ammonium molybdate. The determination by electrolysis offers the same advantages as have been previously mentioned, so that it is possible to determine, both rapidly and accurately, iron, manganese, and phosphoric acid in the same solution without the use of ammonium molybdate. The iron is first separated, as previously described, from the manganese, and the latter is precipitated as the peroxide. The liquid filtered from this precipitate will contain all the phosphoric acid. For determining the same, the liquid is acidified with hydrochloric acid and one-third its volume of ammonium hydrate, and then magnesium chloride solution is added.‡

The precipitate of magnesium ammonium phosphate may be filtered in the course of a few hours, and then it is converted in the ordinary manner into magnesium pyrophosphate.

The above method must also be used when only the phosphoric acid is to be estimated.

If the solution, having been freed from iron and partly so from manganese, and without being treated with sodium hypochlorite, is used directly for determining the phosphoric acid, the remainder of the manganese would be precipitated as phosphate with the ammonium magnesium phosphate, and therefore the result would be too high. For the estimation of phosphorus in pig iron, not more than two grammes should be taken, for this quantity can be precipitated in about two hours; while a large quantity, on account of the poor conducting quality of the iron, will require a longer time (four grammes iron will take from six to seven hours).

When the percentage of phosphorus is so low that two grammes is not enough, the liquid is divided into two por-

* See SCIENTIFIC AMERICAN SUPPLEMENT, vol. xii., p. 4709.

† An excess of the hypochloride must be avoided, or else the manganese peroxide will go into the solution.

‡ If the acidifying is omitted, and the magnesium chloride solution directly added, crystals of potassium ammonium hydrocarbonate will be separated out with the magnesium ammonium salt, which cannot be washed out afterwards with dilute ammonium hydrate.

tions, and each treated by electrolysis. As the nitrates are not at all adapted for electrolysis, the nitric acid solution is evaporated several times with hydrochloric acid, so converting the nitrates into chlorides, which on the addition of a very slight quantity of hydrochloric acid pass into solution.

SEPARATION OF IRON, MANGANESE, AND SULPHURIC ACID.

It is well known that the determination of sulphuric acid or sulphur in substances which contain iron as their principal constituent (iron ores, pig iron) presents great difficulties. In order to determine sulphur in iron ores it is necessary to fuse them with sodium carbonate, or if the sulphur is to be determined in iron, it is converted into hydrogen sulphide, and this, in some way, is oxidized to sulphuric acid. By the employment of electrolytic methods the estimation of sulphuric acid or sulphur becomes as simple as the estimation of phosphoric acid. The method is also similar, for the iron and the manganese are converted into soluble double salts by potassium and ammonium oxalate, and then electrolyzed. The precipitation of the sulphuric acid can be effected directly in the liquid filtered from the manganese peroxide (without previously separating the last traces), it is only necessary to acidify with hydrochloric acid, and then to precipitate the boiling solution with barium chloride. For the determination of sulphur in iron it is digested with nitric acid, and then the nitrates are converted into chlorides, as has previously been described.

SEPARATION OF IRON, MANGANESE, AND ALUMINUM.

In the previous communication* it is mentioned that in the electrolysis of ferrous ammonium oxalate and aluminum ammonium oxalate, the iron is first precipitated in its metallic form, and then the aluminum as hydrate, provided, however, that a sufficient quantity of ammonium oxalate is dissolved in the solution. For the separation of iron, manganese, and aluminum, the solution of the double oxalates is submitted to electrolysis, and the current is broken just as soon as all the iron is reduced.† The liquid is now poured off, and boiled, in order to decompose any ammonium salts, and then precipitated hot by a solution of sodium hydrate in excess, with the addition of a few cubic centimeters of sodium hypochlorite. The peroxide is immediately filtered off, washed with hot water to which some ammonium nitrate has been added, and so converted into the trimanganotetroxide (Mn_3O_4). The alumina is precipitated from the filtrate by adding ammonium chloride, and boiling.

SEPARATION OF IRON, MANGANESE, ALUMINUM, AND PHOSPHORIC ACID.

When phosphoric acid is present in the above mixture it is impossible to precipitate the manganese as peroxide in the previously described method. Aluminum phosphate will be precipitated with it, even when the peroxide is redissolved and the precipitation repeated. Neither citric acid, tartaric acid, nor glycerine will prevent the precipitation of the aluminum phosphate. The presence of phosphoric acid with alumina requires the separation of the manganese as sulphide.

The process is at first the same as usual; the double oxalates are submitted to electrolysis, and the liquid, freed from iron, is poured into a beaker. The manganese peroxide, which adheres to the positive electrode, is dissolved in hydrochloric acid, mixed with an excess of sodium hydrate, and added to the solution. Tartaric acid, and then ammonium hydrate to slightly alkaline reaction, and finally ammonium sulphide are added. After three or four hours' standing, all the manganese is precipitated as the green sulphide, which may then be estimated in the conventional manner. The advantage of electrolysis in determining phosphoric acid is of little use in this case. It is best to precipitate the phosphoric acid in a separate solution with the molybdic reagent.

SEPARATION OF IRON AND CHROMIUM.

If a solution of ferrous ammonium and chromium ammonium oxalate is submitted to electrolysis, the iron must first be separated in its metallic form, and then the chromium oxide is oxidized to chromic acid. In the presence of chromium the separated iron has a brilliant luster. After the iron has been completely removed, the liquid is poured off, reduced by boiling with hydrochloric acid and alcohol, and the chromium precipitated as hydroxide by ammonium hydrate.

SEPARATION OF IRON, MANGANESE, AND CHROMIUM.

This method is essentially the same as the previous one. When the yellow coloration of the chromic acid is produced, the liquid is poured off, boiled to decompose the ammonium hydrocarbonates, precipitated hot by sodium hydrate, to which a few cubic centimeters of sodium hypochlorite have been added. The precipitated manganese always contains some chromium. When it has been filtered it is redissolved in hydrochloric acid, and the precipitation with sodium hydrate and sodium hypochlorite repeated. In the solution filtered from the manganese peroxide, the chromium is determined as above.

SEPARATION OF IRON, MANGANESE, CHROMIUM, AND ALUMINUM.

The separation of iron, manganese, and chromium is accomplished as in the previous instance. The liquid filtered from the manganese peroxide is mixed with an excess of ammonium chloride, and boiled until all the alumina is precipitated. It is then filtered and determined in the ordinary way. The filtrate contains all the chromium in the form of chromic acid. This is reduced by hydrochloric acid and alcohol, and estimated as has previously been described.

SEPARATION OF NICKEL AND MANGANESE.

In the electrolysis of liquids which contain nickel and manganese in solution as double oxalates, the nickel is first precipitated as the metal and the manganese is thrown down as peroxide. The separation of the nickel takes place very rapidly; the separated metal adheres very firmly to the electrode. To determine the manganese in the solution, the ammonium hydrocarbonate is first decomposed by boiling, and then a few cubic centimeters of the sodium hypochloride are added. As regards the further treatment of the precipitate, enough has previously been given.

SEPARATION OF COBALT AND MANGANESE.

This process is precisely identical with the one just given.

* See Scientific American Supplement, vol. xii., p. 4769.

† If the current is allowed to continue until the aluminum is precipitated, the latter will be thrown down on the iron so permanently that it becomes necessary, after the liquid is poured off, to dissolve the iron in oxalic acid, and after neutralizing it with ammonium oxalate, to repeat the electrolysis.

SEPARATION OF ZINC AND MANGANESE.

Again the process is similar to the preceding method. The zinc does not adhere as firmly to the electrode as does the nickel or cobalt, and therefore the washing must be very carefully performed. Excellent results are obtained by this method.

SEPARATION OF COPPER, BISMUTH, AND CADMIUM FROM MANGANESE.

Precisely the same as the foregoing methods.

SEPARATION OF IRON FROM GLUCINA.

The conventional method of separating these two substances is by mixing the liquid with a saturated solution of ammonium carbonate in excess, and then dissolving out the glucina. From this solution the latter is thrown down by boiling. The method does not, however, give entirely satisfactory results. It is necessary to continually treat the glucina with ammonium carbonate, and therefore the separation of this body becomes a very tedious operation. By using the galvanic current the separation may be effected without the slightest inconvenience or difficulty, provided the solution of the double salt is prepared with ammonium oxalate (without potassium oxalate), that an excess of the ammonium oxalate is always kept in the solution, and that the iron is removed with a feeble current. Strong currents cannot be used, for they heat the solution, and the ammonium hydrocarbonate formed by the electrolysis, which keeps the glucinum in solution, is decomposed. It is then possible to separate the glucina before the iron becomes reduced by the current.

SEPARATION OF IRON, GLUCINA, AND ALUMINA.

The process in this case is similar to the preceding method. After the iron is reduced, the solution is poured into another platinum dish, and the electrolysis continued until all of the alumina is precipitated as hydroxide. In the filtrate, the glucina is thrown down by boiling. It is best to redissolve the alumina obtained, and to repeat the electrolysis.

SEPARATION OF IRON FROM ZIRCONIA.

Similar to the separation of iron from glucina.

SEPARATION OF IRON AND VANADIUM.

This separation is also effected in the same manner as described in the separation of the iron from glucina.—*Berichte der Deutschen Chemischen Gesellschaft*, xiv., 2771.

ON THE MANUFACTURE OF THE POTASSIUM AND SODIUM CARBONATES BY THE DIRECT TREATMENT OF THE CHLORIDES WITH TRIMETHYLAMINE.

The Solvay process for the production of sodium bicarbonate is not, as is well known, applicable to the manufacture of potassium bicarbonate. Messrs. J. Ortlieb and A. Muller have recently devised a process by the use of which it is possible to replace the ammonia with trimethylamine as a means of effecting the transformation of potassium chloride into the bicarbonate. This process has been patented, and is now carried on with great success and on a large scale at the factory of chemical products of Croix, near Lille. Thanks to the investigations of M. C. Vincent, trimethylamine obtained from the distillation of the waste liquors of the sugar beet has become a commercial product.

The house of Tilley Delaune, at Courrières, manufactures daily 1,800 kilogrammes of the crude salts of methylamine. Commercial trimethylamine contains, it is true, small quantities of other bases, but they have no effect on its employment.

After having described certain preliminary experiments, the authors, in discussing the theory of the operation, describe their study of trimethylamine carbonates. After passing a current of carbon dioxide into the commercial trimethylamine, whose density is 0·8896 at 20° (and when boiling point is about 48°), and the absorption of carbon dioxide begins to diminish, the current is arrested and the product obtained has the composition of the neutral carbonate of trimethylamine, containing 28 per cent. water of crystallization. This solution (sp. grav. 1·088 at 20°) begins to boil at 75° and the thermometer slowly rises to 102°. At the commencement of the distillation there is condensed in the neck of the retort a crystalline substance which disappears during the operation. When a current of air is passed through the solution the carbonate is altered into the trimethylamine.

On continuing the passage of carbon dioxide into the neutral carbonate of trimethylamine, the absorption progresses very slowly, and is completely arrested when the composition of the product becomes equivalent to that of the sesquicarbonate. As an intermediate product, the authors found a subsesquicarbonate, a combination of one molecule of the neutral carbonate, and of one molecule of the sesquicarbonate. This intermediate product is found in the mother liquors of the transformation of the potassium chloride into the bicarbonate. With reference to the bicarbonate, it cannot exist at ordinary temperatures or under ordinary pressure.

Fundamental Reaction.—When a current of carbon dioxide is passed into a mixture of equal parts of the neutral carbonate of trimethylamine and of potassium chloride (one molecule of the first and two of the latter), a saturated aqueous solution, at 23°, there will be obtained a precipitate of potassium bicarbonate, which represents 38·7 per cent. of the potassium chloride taken. The result will be increased to 60·8 per cent. when the two salts are dissolved in a saturated solution with potassium bicarbonate, that is to say that 45 per cent. of the potassium chloride has undergone transformation. The result is the same if the potassium chloride is placed in suspension in the trimethylamine carbonate.

The previous reaction is limited by the inverse reaction of the potassium bicarbonate on the trimethylamine chlorhydrate. This inverse reaction is quite complex, for, in addition to the double decomposition produced, there is an immediate decomposition of the bicarbonate into carbonic acid, which is given off, and the sesquicarbonate which remains behind. The above experiments are what takes place in the mother liquors. At 150°, the action of carbon dioxide on a mixture of the trimethylamine and of potassium chloride fails to yield any trace of potassium bicarbonate. On the contrary, this latter is brought entirely to the condition of chloride according to its action on the methylamine chlorhydrate in the warm.

Nevertheless, this action may be avoided if the operation is carried on under pressure, at 115°, in such a manner as to prevent the escaping of the carbon dioxide. It may be seen from the examples shown above that the most favorable reaction has produced the transformation of 45 per cent. of potassium chloride into the bicarbonate. It was thought, and experiments have confirmed the theory, that in the presence of an excess of trimethylamine, the reaction will be more complete. The excess of trimethylamine to be used is represented by the quotient of the theoretical decomposition, 100, by the coefficient of the decomposition, 45, obtained by the experiment, equal to 2·22 equivalents of trimethylamine carbonate for one equivalent of potassium chloride (2·22 molecules of the first for two molecules potassium chloride). The reaction in this case yields 97·12 per cent. of potassium chloride. The excess of trimethylamine will be found in the mother liquors in the form of subsesquicarbonate; the remainder is converted into sesquicarbonate.

The solubility of the potassium salts, in the presence of salts of methylamine forming the mother liquor, is an important question for our consideration. The following are the results of determinations made on solutions having the specific gravity of the mother liquors.

	Dissolved salts in 100 parts. KCl.	$KHCO_3$.
Trimethylamine chlorhydrate.	2·6	3·8
Neutral carbonate................	10·8	5·8
Sesquicarbonate..................	double decomposition.	2 15

As shown, the maximum solubility is in the neutral carbonate of trimethylamine. The foregoing experiments, made with the greatest care, and which we have very briefly rehearsed, are the salient points of the industry created by the inventors. As to its application, although the principles greatly resemble those of the Solvay process, it is necessary to use apparatus which are entirely different, and which are required by the different conditions under which the reactions take place, and by the recovery of the trimethylamine. The operations proceed with the greatest regularity, and the most serious objection appears to be the production of carbonic acid. This gas may be produced either by the combustion of coke, or by the decomposition of limestone, or by combinations of these two methods. The gases of combustion are necessarily mixed with the nitrogen of the air; that of a good heating furnace rarely develops more than 30 per cent. carbon dioxide, a quantity which may go down to 12 or 16 per cent. This large dilution, in addition to increasing the volume of gas necessary for use, also favors the employment of trimethylamine. While the practical information relative to the employment of this process was omitted in the memoirs of the inventors, still we have thought it desirable to place before our readers this new phase of the potash industry.—*Bull. Soc. Chim., Paris*, xxxvii., 45.

OBSERVATIONS ON THE PREPARATION AND USE OF THE MOLYBDIC SOLUTION.

By M. Kupfferschlaeger.

A number of methods have been recommended by various chemists for the preparation and employment of this reagent, but the best seems to be ordinary phosphoric acid. In order to describe them more particularly, we shall consider them under six heads. According to the first, ammonium molybdate is dissolved in water, and, little by little, dilute nitric acid is added in excess, with constant stirring. In the second case, molybdic acid is dissolved in dilute ammonium hydrate, and then this solution is poured into an excess of dilute nitric acid, also with continual stirring. A third method is by pouring dilute nitric acid, little by little, with stirring into a solution of ammonium molybdate; by this the separation of molybdic acid is prevented, which would take place, it is said, if the reverse be performed, in consequence of the excess of nitric acid existing from the beginning of the operation. According to a fourth method, hydrochloric acid instead of nitric should be used to acidulate the solution of ammonium molybdate, on account of its preserving the molybdic acid better in solution. By the fifth method, it is desirable to add a little tartaric acid to the solution of potassium molybdate before adding the nitric acid; in this way the precipitation of the molybdic acid is prevented. Finally, according to a sixth method the solution of ammonium molybdate should not be previously acidulated, for after a while it displaces the molybdic acid, but it is preferable to acidulate the solution containing the substance supposed to contain either the phosphoric or arsenic acid.

We have tried each one of these methods, and, according to our experiments, it is immaterial whether the acid is poured into the ammonium molybdate solution or the latter into the acid, provided, however, that sufficiently dilute solutions are used, and that the one is poured into the other, little by little, with continual stirring. A porcelain dish will best serve for this purpose.

If there are chemists who have not been successful in obtaining a clear and complete solution by one or another of these methods, it is because they have used too concentrated a solution, or else that the liquids have been poured too rapidly one into the other, or that they were not continually agitated from the commencement of the operation, or because the molybdic acid was not entirely pure.

But, is it really necessary to previously acidulate the solution of ammonium molybdate? Bolley, in his "Manuel des Essais et Recherches Chimiques," says "that it is not essential to add acid to ammonium molybdate which one desires to preserve, because, under any circumstances, after a while molybdic acid will separate." Chancel, in his "Precis d'Analyse Chimique," says: "Before using a solution of ammonium molybdate, it should be mixed with an excess of hydrochloric acid, in such a manner that the precipitate which has been formed may be redissolved and then boiled." This is not so far in advance of the fact that it is necessary to add acid. Every one has observed that after a while a hard yellow deposit forms in the solution of ammonium nitric molybdate; a fact which suggests the advisability of not preparing the solution, except for immediate uses, and then not too long in advance. Of what is this deposit composed? Having examined the precipitate from a number of bottles which had been filled with molybdic solution for three months or more, we proved to our satisfaction that it consisted, almost exclusively, of the yellow anhydrous molybdic acid with a little ammonium nitrate mixed in the mass.

It is unnecessary to relate the experiments by which we proved the existence of these two compounds. Our readers are sufficiently well informed as to how the methods of procedure are. The clear solutions deprived of their deposits were examined three months later; no further precipitate was perceptible, although they very quickly threw down a yellow sediment when brought in contact with several drops of a solution of sodium phosphate contained in a centiliter

of water. What consequences may be drawn from these facts? It appears evident that nitric acid will in time replace the molybdic acid; that the liquid thus diluted (for it contains less of the reagent) is still sufficiently delicate for the detection of minute traces of orthophosphoric acid; that it is ill advised to previously add a free acid if the prevention of the deposit is desired, or at least to dilute it with a sufficient quantity of water in order to prevent this result, because once precipitated, molybdic acid can not be redissolved by the addition of water. Therefore, according to our experiments, the two causes which may modify the composition of the molybdic solution are the previous addition of nitric acid and the use of an insufficient quantity of water.

Among the receipts thus far proposed for the preparation of ammonium nitromolybdate, more stable than the others, because it prescribes for the use of less nitric acid and a larger quantity of water, we cite the following of MM. Champion and Pellet: Dissolve 10 grammes of molybdic acid in 15 cubic centimeters of ammonium hydrate diluted by 8 c. c. of water, then pouring this clear solution, drop by drop, with stirring, into 50 c. c. of nitric acid diluted with 30 c. c. of water, and then allowing this mixture to stand for several days at a temperature of 40° to 45°, so that any silicic or phosphoric acid that it may contain will be allowed to settle out; then it is decanted and the solution preserved in a well stoppered bottle.

We have satisfied ourselves that by still further increasing the quantity of water, that it is to say, 30 c. c. to the 15 c. c. of ammonium hydrate, and 50 c. c. to 50 c. c. of the nitric acid, there will result a very sensitive reagent, and which at the end of two months will not have deposited anything from its solution. Under any circumstances, whatever may be its degree of dilution, the molybdic solution will show or indicate the slightest traces of orthophosphoric acid.

But as we belong to the small number of chemists who believe that it is not necessary to previously add acid to the solution of ammonium molybdate, and above all tartaric acid, we would recommend that no such addition be made, whenever it is certain that the solution contains neither phosphoric acid nor arsenic acid nor silicic acid; the reason will soon be made apparent.

Turning now to the consideration of the second point of our subject, the use of the molybdic solution: the same discord exists equally among chemists in regard to the employment of this reagent.

According to the majority, the substance under examination is brought into solution by nitric acid, diluted to a considerable extent, and then poured into an excess of ammonium nitromolybdate solution, well agitated and then set away, and allowed to stand at a temperature of 40° to 45° or more.

It is stated by others that an excess of the ammonium nitromolybdate should be poured into the diluted solution of the substance, prepared by nitric or hydrochloric acid, and then allowed to stand. According to a third party, the substance is dissolved in an excess of one or the other of the two acids mentioned, and then there is added to it an excess of ammonium molybdate (not the ammonium nitromolybdate); the mixture must then be boiled and allowed to stand.

The operation is considerably simplified, so say these latter, because it is sufficient to make an aqueous solution of the ammonium molybdate (of whose purity one is certain) at the moment when it is to be used, and then to pour an excess of it into the nitric or hydrochloric solution of the substance under examination, and boil it.

We have satisfied ourselves that by each of these three methods one may successfully determine the phosphoric or arsenic acid, provided that the reagent be in excess of the amount of the acid sought for (because, in the contrary case, the yellow precipitate which forms at first becomes redissolved); and that the hydrochloric or nitric acid does not, either of them, contain any lead, silver, tin or, antimony, and they are not contaminated by the presence of organic substances; above all, no tartaric acid should be added to the mixture, although it is recommended by Fresenius.

In conclusion, if one is assured of the purity of the ammonium molybdate, which may be bought or prepared by one's self, it is best to dispense with the preparation of ammonium nitromolybdate in advance, and to proceed with the estimation by one or the other of the methods which we have just described.—*Journal de la Société Chimique de Paris*, vol. xxxvi., p. 644.

DETECTION OF SILK, WOOL, LINEN, AND COTTON IN FABRICS, WITH A METHOD FOR THEIR QUANTITATIVE ESTIMATION; ALSO THE DETERMINATION OF THE SIZING AND COLORING MATTER.

In hunting for a method by which the qualitative and quantitative estimation of silk, wool, linen, and cotton may be made when they occur together in the same fabric, much useful information may be obtained, but a properly connected method of analysis has only recently been published (by Remont). Therefore most of our readers will appreciate its reproduction in full, especially as it is often necessary to make the examination of a fabric which contains these substances together.

QUALITATIVE EXAMINATION.—The sample to be analyzed is boiled for fifteen minutes in water, to which five per cent. of hydrochloric acid has been added; it is washed, dried, and a thread is then burned:

1st. Nitrogenous odor; a thread is then heated with sodium carbonate; ammoniacal odor; several threads are boiled with basic zinc chloride.—(See below, 2d.)

A. Is completely dissolved. SILK.

B. On adding concentrated hydrochloric acid, a heavy flocculent precipitate forms.	Silk, with wool or vegetable fiber. For residue, see C.
C. The sample is not dissolved in zinc chloride. The sample is then treated with a dilute solution of boiling sodium hydrate.	Completely soluble. WOOL. Partially soluble. LINEN and COTTON.

2d. If no odor of nitrogeneous matter is obtained. VEGETABLE FIBER.

In order to distinguish between the vegetable fibers of cotton, flax, and linen, a microscopical examination is necessary. The preliminary examination determines either silk, wool, or cotton.

Sampling.—Four samples of two grammes each are taken, and three portions are examined, the fourth is reserved.

Detection of the Size and Coloring.—The sample is dipped into about 200 cubic centimeters of a three per cent. solution of hydrochloric acid, and boiled for fifteen minutes. If the liquid becomes very much colored it is decanted, and the sample boiled for an additional fifteen minutes with dilute hydrochloric acid, then the substance is well washed with water, and dried; the operation is hastened by drying between pieces of linen. Cotton becomes decolorized very fast, wool less rapidly, and silk only partially. Light aniline colors can be neglected in the examination of silk, for the weight is slight; this, however, must not be done in the case of dark, and especially black silks. Aniline black is seldom used to dye silks, but iron black (nitro-sulphate of iron), with which the fiber can be mixed to two-thirds its weight, is commonly employed. This iron black may be completely removed as long as it does not exceed one-fourth the weight of the fiber; beyond that the decolorization is only partial, as may be shown by burning a sample of the washed specimens.

Separation of the Silk.—One of the portions which has been treated by boiling is laid one side, and the remaining two are dipped into a solution of the basic zinc chloride of 60° B. This reagent is prepared by heating together a mixture of 1,000 parts fused zinc chloride, 850 parts distilled water, and 40 parts zinc oxide, until a solution is formed. The two samples are then washed until no further precipitate can be obtained with ammonium sulphide in the wash water. The operation is greatly hastened if the fabric be dried between pieces of linen.

Separation of the Wool.—One of the samples freed from silk is laid aside, and the other one is treated in 60 to 80 cubic centimeters of caustic soda (prepared by dissolving one part of caustic soda of 36° B. in 20 volumes of water) brought to a slight boil, which is kept up for fifteen minutes, wash as before, being careful to avoid any loss.

Drying and Weighing.—The four samples are dried for an hour at 100°, then exposed to the air until the following day, when they are weighed. The sample which has not yet been treated should weigh two grammes. The difference in weight between the latter and the sample treated with acid gives the *size* and *coloring matter*. If from the weight of the second piece the weight of the sample treated with zinc chloride be subtracted the difference will be the weight of the *silk;* the fourth consists of *vegetable fiber*, from which, according to experiments by the author, about five per cent. must be added, to make up for the loss produced by boiling with sodium hydrate. The weights may now be converted into percentages by multiplying by 50. The difference between their sum and 100 is equivalent to the percentages of *wool*.

In the laboratory of the *Chemiker Zeitung* a series of experiments were made according to the above description, and we would observe that the zinc chloride was removed by washing the sample with a large quantity of boiling water, to which a few drops of nitric acid had previously been added; by its use the operation was considerably accelerated.

The basic zinc chloride, on cooling, separates out in crystals, which, on heating, always redissolve.

The degrees Baumé given for this solution correspond to a density of 1·690, while the caustic soda calculated to percentages is equivalent to 1·5 per cent.

We always used, as prescribed above, two grammes for each determination, and calculated their weights to centigrammes.

1. WHITE LINEN.—On being burnt gave a nitrogenous odor.

Weight on drying, almost unchanged.		
" after boiling with hydrochloric acid,	1·70	grms.
Size and *impurities*	15·00	"
Weight after treatment with basic zinc chloride, 1·70 grms. *Silk*	0·00	"
Weight after treatment with caustic soda, nearly 1·70 grms. *Wool*	0·00	"
By the microscope. *Linen*	85·00	"
	100·00	"

2. FELT (BROWN.)—Slight odor after being burnt.

Weight, after drying, almost unchanged.		
" " boiling with hydrochloric acid	1·75	grms.
Size and *coloring*	12·50	"
Weight after treatment with basic zinc chloride, 1·75 grms. *Silk*	0·00	"
Weight after treatment with sodium hydrate, 1·10 grms. *Wool* (less 5 per cent.).	40·00	"
By the microscope. *Cotton*	47·50	"
	100·00	"

3. SHIRTING.—No odor after burning.

Weight, after drying, unchanged.		
" " being boiled with hydrochloric acid	1·70	grms.
Size	15·00	"
Weight after treatment with zinc chloride, 1·70 grms. *Silk*	0·00	"
Too much decomposed to be treated with caustic soda, hence no *wool*	0·00	"
By the microscope. *Cotton*	85·00	"
	100·00	"

4. GRAY SATIN.—An odor of nitrogen after burning.

Weight, after drying, almost unchanged.		
" " boiling with hydrochloric acid	1·55	grms.
Size and *color*	22·50	"
Weight, after treatment with zinc chloride, 1·20 grms. *Silk*	12·50	"
Weight, after treatment with caustic soda, 1·15 grms *Wool*	0·00	"
By the microscope. *Linen*	65·00	"
	100·00	

5. HARD MATERIAL, dyed with Prussian blue. Odor of nitrogen.

Weight after drying, almost unchanged.		
" " treatment with hydrochloric acid	1·175	grms.
Size and *color*	12·50	grms.
Weight after treatment with basic zinc chloride, 1·25 grms. *Silk*	25·00	"
Completely soluble in caustic soda. Wool.	62·50	"
	100·00	

6. GRAY WOOLEN CLOTH Odor of nitrogen.

Weight, after drying, almost unchanged.		
" " boiling with hydrochloric acid	1·9	grms.
Size and *color*	5·00	"
Weight after treatment with basic zinc chloride, 1·86 grms. *Silk*	0·00	"
Entirely dissolved by caustic soda. *Wool*	95·00	"
	100·00	

This method is not adapted to the analysis of heavy weighted silks. In a sample examined, after boiling for thirty minutes with hydrochloric acid and then digesting for five hours, a considerable quantity of iron was found to be present. The weighting was therefore determined according to the method given by E. Königs. The silk left 16·03 per cent. of ash free from lead and zinc. The percentage of Prussian blue was 5·50, and ash 3·66 per cent. Taking the ash of the silk as 0·4 per cent., there will be left 11·97 per cent. as the iron. In order to estimate the quantity of tannate of iron (weighting) this number, according to Königs, is multiplied by 5·1. From this we determine the composition of the silk to be:

Tannate of iron	61·05
Prussian blue	5·50
Silk	33·45
	100·00

—*Chemiker Zeitung*, v., 972.

ESTIMATION OF NICOTINE IN TOBACCO.

By R. KISSLING.

THE author begins by discussing the different methods proposed for the estimation of nicotine, more especially those of Schloesing and Dragendorff. The former of these two methods fails to give correct results, because in many instances a portion of the ammonium hydrate is apt to be estimated as nicotine, and therefore it cannot be recommended; also, it is very difficult to titer in a colored and cloudy liquid; while the second method, titering with potassium mercury iodide, is likewise not to be used, because fermented tobacco always contains acetic acid, or other organic acids, and the end of the titration cannot easily be determined, for clear solutions cannot be obtained even after filtering. Excellent results were obtained by the author in using the following method. The stripped and cut tobacco is dried at 50°–60° for one to two hours, and then coarsely pulverized; twenty grammes of the powdered material are carefully moistened with ten cubic centimeters of alcoholic solution of sodium hydrate (6 grammes sodium hydrate dissolved in 40 c. c. water and 60 c. c. of 95 per cent. alcohol added), and then placed in a paper capsule and extracted with 100 c. c. of ether for two to three hours in a Tollen's extractor. The ether is carefully but not completely distilled off; 50 c. c. of dilute sodium hydrate (4 grammes sodium hydrate in 1,000 c. c. water) are added, and 400 c.c. are distilled off in a current of steam, and the distillate collected in four portions of 100 c. c. each. The distillates are each separately titered with sulphuric acid, using rosolic acid as an indicator.—*Zeitschrift Anal. Chem.*, 21, 64.

THE ANALYSIS OF WINES.

By DR. J. NESSLER and DR. M. BARTH.

1. *The Determination of the Extract in Wine.*—Fifty cubic centimeters of the wine are evaporated to the consistency of a sirup over a water-bath, and the residue is dried for three hours at 100° in an air-bath. The loss of glycerine is very slight, and the change in the other constituents of the extract is insignificant. The method, by Grete, for determining the extract—by adding a measured quantity of barium water of known strength, and drying for eight hours at 110° to 115°— has given good results for normal wines, but can not be altogether recommended, for the charactor of the extract gives no clew to the purity of the wine, and also because wines which have become acid, as well as those which contain much glycerine, appear rich in extract. In order to ascertain the amount of glycerine present, the extract may first be determined by Grete's method, and then evaporating and drying under the air-pump until a constant weight is obtained, the difference between the weights obtained will correspond approximately to the glycerine and volatile acid that are present. The authors suggest as a minimum for the extract ten per mille, after deducting the total acid, and eleven per mille after the fixed acid has been deducted. A higher percentage of extract will be found in wines still containing unfermented sugar, also from certain wines from districts where experience has shown that the product has more body; and finally, also in red wines from which a minimum of twelve per mille of acid free extract is obtained. The ash of genuine wines was found to be not less than 1·4 per mille.

2. *On a Modification of Neubauer's Test for Glucose in Wines, and on the Optical Behavior of Pure and Sugared Wines.*—The method of precipitation by ether, proposed by Neubauer was found, according to the writers of this article, to yield negative results, for the reason that ether fails to remove any of the polarizing substances from the aqueous alcoholic solution; and also attention is directed to the importance of separating the tartaric acid, which even in a one per cent. solution will turn 0·3° R. in a 200 mm. tube. It is, therefore, recommended that 210 c. c. of the sample of wine be evaporated to a thin sirup, with the addition of a few drops of a concentrated solution of potassium acetate, treated with 90 per cent. of alcohol and filtered, when the liquid becomes clear; then evaporated to 15 c. c. with water and animal charcoal, again filtering and washing to 30 c. c., and finally polarizing; if the plane of polarization is turned as much as 0·6° to the right, the wine may safely be considered as containing glucose. The presence of unfermented cane sugar is detected by polarization to the right before, and to the left after immersion, evaporating with a few drops, and then diluting to the original volume. It is impossible to detect cane sugar optically. Coloring the wine by caramel has no effect on the optical behavior of the wine.

3. *On the Determination of Chlorine in Wine.*—In order to increase the percentage of extract or ash in adulterated wines, it is a common practice to add sodium chloride, or else water containing a large amount of solids. Therefore, the estimation of chlorine often becomes of particular interest. The method of its determination cannot be effected by titration by silver nitrate with potassium dichromate as an indicator, even after the wine has been neutralized, and hence a modification of Volhard's method

has been employed; by its use, good results can be obtained when the wines have been decolorized by animal charcoal. The ash in wines containing sodium chloride will not burn white, and even after the most careful incineration a loss of chlorine cannot be avoided. Genuine wines contain at most 0·05 per cent., but generally less than 0·002 per cent., of chlorine. At the experiment station at Carlsruhe, wines have been examined that contained 0·020 per cent. chlorine.

4. *The Detection of Free Tartaric Acid in Wines.*—This is effected by evaporating 100 c. c. of wine down to a thin sirup, and then separating the argol by the addition of a sufficient quantity of alcohol, and allowing it to stand for two hours. The filtrate is freed from alcohol by evaporation, decolorized with animal charcoal, filtered, and the filtrate, which amounts to about 10 c. c., is mixed with 1½ to 2 c. c. of a twenty per cent. solution of calcium acetate. Wines which contain 0·05 per cent. of free tartaric acid will, at the end of half an hour, deposit a distinct crystalline precipitate of calcium tartrate, which adheres to the bottom and sides of the vessel. A wine containing 0·01 per cent., will give small, distinct crystals at the end of two hours. The free acid, even in wines made from partly unripe grapes, never exceeds one-sixth of the non-volatile acids present.

5. *The Determination of Citric Acid in Wine.*—Citric acid is often added to wines directly as such, or else in the form of tamarinds. These give body to the wine and produce an aged appearance. For its detection, the following method is recommended by the authors: 100 c. c. of the sample are concentrated to seven c. c.; when it is cooled, eighty per cent. of alcohol are added, and the liquid filtered. The alcohol is driven off by heat and the residue concentrated with water to twenty c. c. A portion of the acid is neutralized with milk of lime (red wines must be decolorized by means of animal charcoal) and filtered.

The acid filtrate is diluted to 100 c. c., then from 0·5 to 1 c. c. of a cold, saturated solution of lead acetate is added, and the mixture violently shaken. The precipitate is first washed with cold water, and then with the filter it is shaken with hydrogen sulphide water; after being allowed to stand for some time, the liquid is filtered and the hydrogen sulphide removed by heating. The solution, which should now be equal to about 15 c. c., is made slightly alkaline by adding lime-water. In order to precipitate any phosphoric acid present, the filtrate is now slightly acidulated with acetic acid, and after standing for an hour, it is filtered from the calcium tartrate which may have formed. The filtrate is evaporated to dryness, the residue taken up with hot water, again concentrated until the calcium citrate separates out. The precipitate is then washed with hot water and weighed. Its composition corresponds to the following formula: $(C_6H_5O_7)_2Ca_3 + 4H_2O$. Of twenty milligrammes citric acid added to a wine, thirteen were recovered by the above method. Most of the wines examined were, however, found to be free from any appreciable quantities of citric acid. A white wine from Alsace (1878) contained 0·003 per cent., and a white wine from Italy 0·002 per cent. of citric acid.—*Zeitschrift Anal. Chem.*, xxi., 43.

M. B.

TOXIC PROPERTIES OF CHLORATE OF POTASH.

A GREAT sensation has been produced in France by the death of four children from taking chlorate of potash; and a great deal of attention is now being given by the medical world to the effects of chlorate of potash, as revealed in an elaborate paper by Drs. Brousdel and l'Hôte of Paris, in which a number of deaths are recorded, and certain well-intentioned persons are exhibited in the unpleasant light of practicing medicine and pharmacy illegally.

In the following lines we shall exclude all that relates to forensic medicine before the law courts, and confine ourselves strictly and briefly to chlorate of potash considered as a medicament for internal use, administered in ordinary doses; and we cannot view these facts without a feeling of intense astonishment that they have been so long in coming to light.

It is now nearly thirty years since chlorate of potash was introduced into medical practice. It was prescribed especially in angina and inflammation of the mouth. At first it was used with great precaution, but after a while, being prescribed more frequently and in larger doses, accidents began to happen. This is exactly what we have seen to be the case with carbolic acid; it was at first used cautiously like creosote, which it so closely resembles, but then as "familiarity breeds contempt," in other terms, as the substance became cheaper, it was used (and is still used) most recklessly, and the number of deaths that can be traced to its use during the last ten years is astonishing.

Chlorate of potash was usually prescribed as a gargle, or as pastilles, and was rarely given internally in France, though in most European countries both medical men and pharmacists seem even now to be quite unacquainted with its real properties. It appears from the statistics of the medicine supplied to the civil hospitals in Paris, that the use of chlorate of potash has gone on steadily increasing since 1855. In that year the hospitals consumed 76 lb. of it; already in 1875, only ten years later, the quantity consumed in these same hospitals had steadily risen to 938 lb. Nevertheless, a warning was given as early as 1855, for in that year the *Journal de Chimie Médicale* gave a case of poisoning by chlorate of potash in that of a man who purchased two ounces of it in mistake for Epsom salts. He divided this quantity into three packets, the first of which produced violent colic, and the second taken on the following day brought on convulsions, of which he died, leaving the third packet untouched. The body of this victim of misfortune took a dark slate color. Several similar occurrences have been recently related in the medical journals by Dr. Jacobi, of New York. The first of these is very extraordinary:

Dr. Fornstain, having read about the medicament in question, determined to try its effects upon himself. He swallowed one ounce of chlorate of potash, and died of nephritis on the seventh day.

Shortly after this a young lady took at short intervals one ounce of chlorate of potash, according to a prescription which stated that it was to be used as a gargle; it appears that she swallowed the liquid each time after gargling, and she died of nephritis in the course of a few days.

A man of thirty years of age took altogether about 1½ ounces of chlorate of potash in the course of six hours, and died of nephritis on the fourth day.

Three drachms of chlorate of potash were given to a child three years of age in the four-and-twenty hours, and the child died next day of nephritis.

Another child little more than a year old died in a few hours after the administration of one drachm of chlorate of potash.

Another case in which chlorate of potash was sold in mistake for Epsom salts occurred in 1880, in Dr. Manouriez's practice at Valenciennes, and was published by him. The medicine was taken at eight o'clock in the morning, and the man died at four o'clock in the afternoon. In this case also there was cyanosis, bronchic rales, and cold perspirations, preceded by vomiting, colic, purging, etc.

Dr Ferrier reports the case of an Irishman thirty-six years of age who died in the course of a day after taking a spoonful of chlorate of potash; and Kauffmann relates the case of a little girl of two years of age, who took about half-an-ounce of chlorate of potash and died in seven hours, with vomiting and coma.

On the 22d October, 1880, the well-known Professor Billroth, of Vienna, called attention to the death of a man sixty four years of age, which he could only attribute to the fact of his having taken small doses of chlorate of potash, about a quarter of an ounce once a day; and on this occasion Dr. Brenner made known two other cases. The same year Dr. Wegscheider related 31 cases of poisoning by chlorate of potash, of which 25 were fatal. It must be a sad thing for physicians to see their prescriptions leading to such dreadful results as these. We could multiply the number of cases, if it were requisite, but we have said enough to rivet the attention of the medical and pharmaceutical world upon this important subject. It is beyond doubt, at present, that the repeated administration of even very small doses of chlorate of potash is extremely dangerous and frequently fatal.—*Monthly Magazine of Pharmacy.*

THE COLORS OF FLOWERS.

BEFORE me, as I write, stands a small specimen vase, containing a little Scotch bluebell, picked upon a bleak, open moorside, yet wonderfully delicate and fragile in stem, and leaf, and bud, and blossom. For the bluebells of Scotland, the bluebells of Walter Scott and of all the old ballad poetry, are not our stiff, thick-stemmed English wild hyacinths, but the same dainty, drooping flowers which we in the south call harebells. The word ought really to be heather-bell; but the corruption is quite in accordance with a common law of English phonology, which has similarly degraded several other early words by dropping out the *th* between two vowels. Harebell or heather-bell or bluebell, the flower is one of our prettiest and most graceful native forms; and the exquisite depth of its color has always made it a prime favorite with our poets and our children alike. How it first got that beautiful color is the problem which I wish, if possible, to settle, to-day.

I am not going to inquire at present why the harebell is colored at all. That question I suppose everybody has now heard answered a dozen times over at least. We all know nowadays that the colors of flowers are useful to them in attracting the insects which fertilize their embryo seeds; and that only those flowers possess bright hues which thus depend upon insects for the impregnation of their ovules. Wind-fertilized blossoms, in which the pollen of one head is carried by chance breezes to the stigma of another, are always small, green, and comparatively inconspicuous. It is only those plants which are indebted to bees or butterflies for the due setting of their seeds that ever advertise their store of honey by bright hued petals. All this, as I say, we have each of us heard long ago. So the specific question which I wish to attack to-day is not why the harebell is colored, but why is it colored blue. And, in getting at the answer to this one test-question, I hope incidentally to answer the wider question why any given flower whatsoever should be blue, let us say, or red, or lilac, rather than orange, yellow, white, or any other possible color in nature except the one which it actually happens to be.

Briefly put, the general conclusion at which I have arrived is this: all flowers were, in their earliest form, yellow; then, some of them became white; after that, a few of them grew to be red or purple; and finally a comparatively small number acquired various shades of lilac, mauve, violet, or blue. So that, if this principle be true, the harebell will represent one of the most highly developed lines of descent; and its ancestors will have passed successively through all the intermediate stages. Let us see what grounds can be given for such a belief.

In the first place, it is well to observe that when we speak of the colors of flowers we generally mean the color of the petals alone. For in most cases the stamens and other central organs, which form, botanically speaking, the really important part of the blossom, are yellow, or at least yellowish; while the petals may be blue, red, pink, orange, lilac, or even green. But as the central organs are comparatively small, whereas the petals are large and conspicuous, we naturally speak of flowers in every-day talk as having the color of their petals, which form by far the greater and most noticeable part of the whole surface. Our question, then, narrows itself down to this: Why are the petals in any particular blossom of one color rather than another?

Now petals, as I have more than once already explained to the readers of this magazine, are in all probability originally enlarged and flattened stamens, which have been set apart for the special work of attracting insects. It seems likely that all flowers at first consisted of the central organs alone—that is to say, the pistil, which contains the ovary with its embryo seeds; and the stamens, which produce the pollen, whose co-operation is necessary in order to fertilize these same embryo ovules and to make the pistil mature into ripe fruit. But in those plants which took to fertilization by means of insects—or, one ought rather to say, in those plants which took to visiting for the sake of their honey or pollen, and so unconsciously fertilizing—the flowers soon began to produce an outer row of barren and specialized stamens, adapted by their size and color for attracting the fertilizing insects; and these barren and specialized stamens are what we commonly call petals. Any flowers which thus presented brilliant masses of color to allure the eyes of the beetles, the bees, and the butterflies would naturally receive the greatest number of visits from their insect friends, and would therefore stand the best chances of setting their seeds, as well as of producing healthy and vigorous offspring as the result of a proper cross. In this way, they would gain an advantage in the struggle for life over their less fortunate compeers, and would hand down their own peculiarities to their descendants after them.

But as the stamens of almost all flowers, certainly of all the oldest and simplest flowers, are yellow, it would naturally follow that the earliest petals would be yellow too. When the stamens of the outer row were flattened and broadened into petals, there would be no particular reason why they should change their color; and, in the absence of any good reason, they doubtless retained it as before. Indeed, I shall try to show, a little later on, that the earliest and simplest types of existing flowers are almost always yellow, seldom white, and never blue; and this in itself would be sufficient ground for believing that yellow was the original color of all petals.* But as I am personally somewhat heretical, in believing, contrary to the general run of existing scientific opinion, that petals are derived from flattened stamens, not from simplified and attenuated leaves, I shall venture to detail here the reasons for this belief, because it seems to me of capital importance in connection with our present subject. For if the petals were originally a row of stamens set apart for the function of attracting insects, it would be natural and obvious why they should begin by being yellow; but if they were originally a set of leaves, which became thinner and more brightly colored for the same purpose, it would be difficult to see why they should first have assumed any one color rather than another.

The accepted doctrine as to the nature of petals is that discovered by Wolff and afterwards rediscovered by Goethe, after whose name it is usually called; for of course, as in all such cases, the greater man's fame has swallowed up the fame of the lesser. Goethe held that all the parts of the flower were really modified leaves, and that a gradual transition could be traced between them, from the ordinary leaf through the stem-leaf and the bract to the sepal (or division of the calyx), the petal, the stamen, and the ovary or carpel. Now if we look at most modern flowers, such a transition can undoubtedly be observed; and sometimes it is very delicately graduated, so that you can hardly say where each sort of leaf merges into the next. But unfortunately for the truth of the theory as ordinarily understood, we now know that in the earliest flowers there were no petals or sepals, but that primitive flowering plants had simply leaves on the one hand, and stamens and ovules on the other. The oldest types of flowers at present surviving, those of the pine tribe and of the tropical cycads (such as the well known zamias of our conservatories), have still only these simple elements. But if petals and sepals are later in origin (as we know them to be) than stamens and carpels, we cannot say, it seems to me, that they mark one transition from one form to the other, any more than we can say that Gothic architecture marks the transition from the Egyptian style to the classical Greek. I do not mean to deny that the stamen and the ovary are themselves by origin modified leaves—that part of the Wolffian theory is absolutely irrefutable—but what I do mean to say is this, that with the light shed upon the subject by the modern doctrine of evolution, we can no longer regard petals and sepals as intermediate stages between the two. The earliest flowering plants had true leaves on the one hand, and specialized pollen-bearing or ovule-bearing leaves on the other hand, which latter are what we call stamens and carpels; but they had no petals at all, and the petals of modern flowers have been produced at some later period. I believe also, they have been produced by a modification of certain external stamens, not by a modification of true leaves. Instead of being leaves arrested on their way toward becoming stamens, they are stamens which have partially reverted toward the condition of leaves. They differ from true leaves, however, in their thin spongy texture, and in the bright pigments with which they are adorned.

All stamens show a great tendency easily to become petaloid, as the technical botanists call it; that is to say, to flatten out their filament or stalk, and finally to lose their pollen-bearing sacs or anthers. In the water-lilies—which are one of the oldest and simplest types of flowers we now possess, still preserving many antique points of structure unchanged—we can trace a regular gradation from the perfect stamen to the perfect petal. In the center of the flower, we find stamens of the ordinary sort, with rounded stalks or filaments, and long, yellow anthers full of pollen at the end of each; then, as we move outward, we find the filaments growing flatter and broader, and the pollen-sacs less and less perfect; next we find a few stamens which look exactly like petals, only that they have two abortive anthers stuck awkwardly on to their summits; and, finally, we find true petals, broad and flat, yellow or white, as the case may be, and without any trace of the anthers at all. Here in this very ancient flower we have stereotyped for us, as it were, the mode in which stamens first developed into petals, under stress of insect selection.

"But how do you know," some one may ask, "that the transition was not in the opposite direction? How do you know that the water-lily had not petals alone to start with, and that these did not afterwards develop, as the Wolffian hypothesis would have us believe, into stamens?" Well, for a very simple reason. The theory of Wolff and Goethe is quite incompatible with the doctrine of development, at least if accepted as a historical explanation (which Wolff and Goethe of course never meant it to be). Flowers can and do exist without petals, which are no essential part of the organism, but a mere set of attractive colored advertisements for alluring insects; but no flower can possibly exist without stamens, which are one of the two essential reproductive organs in the plant. Without pollen, no flower can set its seeds. A parallel from the animal world will make this immediately obvious. Hive-bees consist of three kinds—the queens or fertile females, the drones or males, and the workers or neuters. Now it would be absurd to ask whether the queens were developed from an original class of neuters, or the neuters from an original class of fertile females. Neuters left to themselves would die out in a single generation; they are really sterilized females, set apart for a special function on behalf of the hive. It is just the same with petals; they are sterilized stamens, set apart for the special function of attracting insects on behalf of the entire flower. But to ask which came first, the petals or the stamens, is as absurd as to ask which came first, the male and female bees or the neuters.†

In many other cases besides the water-lily, we know that

* In a part of this article I shall have to go over ground already considered in a valuable paper read by Sir John Lubbock before the British Association at York last August, and I shall take part of my examples from his interesting collection of facts as reported in *Nature*. But, at the same time, I should like at the outset to point out that I venture to differ on two points from his great authority. In the first place, I do not think all flowers were originally green, because I believe petals were first derived from altered stamens, not from altered sepals or bracts, and that modern green flowers are degraded types, not survivals, of early forms. And in the second place, I think yellow petals preceded white petals in the order of time, and not *vice versa*. I may also be excused for adding that I had already arrived at most of the substantive conclusions set forth in this article before the appearance of Sir John Lubbock's paper, and had incidentally put forward the greater part of them, though dogmatically and without stating my reasons, in an article on the "Daisy's Pedigree," published in the *Cornhill Magazine*, and in another on the "Rose Family," published in *Belgravia*, both for August, 1881. At the same time, I must express my indebtedness for many new details to Sir John Lubbock's admirable paper. Of course this note is only appended for the behoof of scientific readers.

† I must add that I do not in the least doubt the truth of Wolff's great generalization in the way in which he meant it—the existence of a homology between the leaf and all floral organs; I only mean that the conception requires to be modified a little by the light of later evolutionary discoveries.

stamens often turn into petals. Thus the numerous colored rays of the mesembryanthemums or ice-plant family are acknowledged to be flattened stamens. In double roses and almost all other double flowers the extra petals are produced from the stamens of the interior. In short, stamens generally can be readily converted into petals, especially in rich and fertile soils or under cultivation. Even where stamens always retain their pollen-sacs, they have often broad, flattened, petaloid filaments, as in the Star of Bethlehem and many other flowers. Looking at the question as a whole, we can see how petals might easily have taken their origin from stamens, while it is difficult to understand how they could have taken their origin from ordinary leaves—a process of which, if it ever took place, no hint now remains to us. We shall see hereafter that the manner in which certain outer florets in the compound flower-heads of the daisy or the aster have been sterilized and specialized for the work of attraction, affords an exact analogy to the manner in which it is here suggested that certain stamens may at an earlier date have been sterilized and specialized for the same purpose, thus giving rise to what we know as petals.

We may take it for granted, then (to return from this long but needful digression), that the earliest petals were derived from flattened stamens, and were therefore probably yellow in color, like the stamens from which they took their origin. The question next arises, How did some of them afterwards come to be orange, red, purple, or blue?

A few years ago, when the problem of the connection between flowers and insects still remained much in the state where Sprengel left it at the end of the last century, it would have seemed quite impossible to answer this question. But nowadays, after the full researches of Darwin, Wallace, Lubbock, and Hermann Müller into the subject, we can give a very satisfactory solution indeed. We now know, not only that the colors of the flowers as a whole are intended to attract insects in general, but that certain colors are definitely intended to attract certain special kinds of insects. Thus, to take a few samples only out of hundreds that might be cited, the flowers which lay themselves out for fertilization by miscellaneous small flies are almost always white; those which depend upon the beetles are generally yellow; while those that bid for the favor of bees and butterflies are usually red, purple, lilac, or blue. Certain insects always visit one species of flower alone; and others pass from blossom to blossom of one kind only on a single day; though they may vary a little from kind to kind as the season advances, and one species replaces another. Müller, the most statistical of naturalists, has noticed that while bees form seventy-five per cent. of insects visiting the very developed composites, they form only fourteen per cent. of those visiting umbelliferous plants, which have, as a rule, open but by no means showy white flowers. Certain blossoms which lay themselves out to attract wasps are, as he quaintly puts it, "obviously adapted to a less æsthetically cultivated circle of visitors." And some livid red flowers actually resemble in their color and odor decaying raw meat, thus inducing bluebottle flies to visit them and to carry their pollen from head to head.

Down to the minutest distinctions between species, this correlation of flowers to the tastes of their particular guests seems to hold good. Hermann Müller notes that the common galium of our heaths and hedges is white, and therefore visited by small flies; while the lady's bedstraw, its near relative, is yellow, and owes its fertilization to little beetles. Mr. H. O. Forbes counted on one occasion the visits he saw paid to the flowers on a single bank; and he found that a particular bumble-bee sucked the honey of thirty purple dead-nettles in succession, passing over without notice all the other plants in the neighborhood; two other species of bumble-bee and a cabbage-butterfly also patronized the same dead-nettles exclusively. Fritz Müller noticed a lantana in South America which changes color as its flowering advances; and he observed that each kind of butterfly which visited it stuck rigidly to its own favorite color, waiting to pay its addresses until that color appeared. Mr. Darwin cut off the petals of a lobelia and found that the hive-bees never went near it, though they were very busy with the surrounding flowers. But perhaps Sir John Lubbock's latest experiments on bees are the most conclusive of all. He had long ago convinced himself, by trials with honey placed on slips of glass above yellow, pink, or blue paper, that bees could discriminate the different colors; and he has now shown in the same way that they display a marked preference for blue over all others. The fact is, blue flowers are, as a rule, specialized for fertilization by bees, and bees therefore prefer this color; while conversely the flowers have at the same time become blue because that was the color which the bees prefer. As in most other cases, the adaptation must have gone on *pari passu* on both sides. As the bee-flowers grew bluer, the bees must have grown fonder and fonder of blue; and as they grew fonder of blue, they must have more and more constantly preferred the bluest flowers.

We thus see how the special tastes of insects may have become the selective agency for developing white, pink, red, purple, and blue petals from the original yellow ones. But before they could exercise such a selective action the petals must themselves have shown some tendency to vary in certain fixed directions. How could such an original tendency arise? For, of course, if the insects never saw any pink, purple, or blue petals, they could not specially favor and select them; so that we are as yet hardly nearer the solution of the problem than ever.

Here Mr. Sorby, who has chemically studied the coloring matter of leaves and flowers far more deeply than any other investigator, supplies us with a useful hint. He tells us that the various pigments of bright petals are already contained in the ordinary tissues of the plant, whose juices only need to be slightly modified in chemical constitution in order to make them into the blues, pinks, and purples with which we are so familiar. "The colored substances in the petals," he says, "are in many cases exactly the same as those in the foliage from which chlorophyl has disappeared; so that the petals are often exactly like leaves which have turned yellow and red in autumn, or the very yellow or red leaves of early spring." "The color of many crimson, pink, and red flowers is due to the development of substances belonging to the erythrophyl group, and not unfrequently to exactly the same kind as that so often found in leaves. The facts seem to indicate that these various substances may be due to an alteration of the normal constituents of leaves. So far as I have been able to ascertain, their development seems as if related to extra oxidization, modified by light and other varying conditions not yet understood."

The different hues assumed by petals are all thus, as it were, laid up beforehand in the tissues of the plant, ready to be brought out at a moment's notice. And all flowers, as we know, easily sport a little in color. But the question is, do their changes tend to follow any regular and definite order? Is there any reason to believe that the modification runs from yellow through red to blue, rather than *vice versa?* I believe there is; and we get hints of it in the following fashion:

One of our common little English forget-me-nots, by name *Myosotis versicolor* (may I be pardoned for using a few scientific names just this once?) is pale yellow when it first opens; but as it grows older, it becomes faintly pinkish, and ends by being blue like others of its race. Now, this sort of color-change is by no means uncommon; and in all the cases that I know of it is always in the same direction, from yellow or white, through pink, orange, or red, to purple or blue. For example, one of the wall-flower tribe, *Cheiranthus chamæleo*, has at first a whitish flower, then a citron-yellow, and finally emerges into a red or violet. The petals of *Stylidium fruticosum* are pale yellow to begin with, and afterwards become light rose-colored. An evening primrose, *Œnothera tetraptera*, has white flowers in its first stage and red ones at a later period of development. *Cobæa scandens* goes from white to violet; *Hibiscus mutabilis* from white through flesh-colored to red. Fritz Müller's lantana is yellow on its first day, orange on the second, and purple on the third. The whole tribe of borages begin by being pink and end with being blue. The garden convolvulus opens a blushing white and passes into full purple. In all these and many other cases the general direction of the changes is the same. They are usually set down as due to oxidation of the pigmentary matter.

If this be so, there is a good reason why bees should be specially fond of blue, and why blue flowers should be specially adapted for fertilization by their aid. For Mr. A. R. Wallace has shown that color is most apt to appear or to vary in those parts of plants or animals which have undergone the highest amount of modification. The markings of the peacock and the argus pheasant come out upon their immensely developed secondary tail-feathers or wing-plumes; the metallic hues of sun-birds and humming-birds show themselves upon their highly specialized crests, gorgets, or lappets. It is the same with the hackles of fowls, the head-ornaments of fruit-pigeons, and the bills of toucans. The most exquisite colors in the insect world are those which are developed on the greatly expanded and delicately feathered wings of butterflies; and the eye-spots which adorn a few species are usually found on their very highly modified swallow-tail appendages. So, too, with flowers; those which have undergone most modification have their colors most profoundly altered. In this way, we may put it down as a general rule (to be tested hereafter) that the least developed flowers are usually yellow or white; those which have undergone a little more modification are usually pink or red; and those which have been most highly specialized of any are usually purple, lilac, or blue. Absolute deep ultramarine, like that of this harebell, probably marks the highest level of all.

On the other hand, Mr. Wallace's principle also explains why the bees and butterflies should prefer these specialized colors to all others, and should, therefore, select the flowers which display them by preference over any less developed types. For bees and butterflies are the most highly adapted of all insects to honey-seeking and flower-feeding. They have themselves on their side undergone the largest amount of specialization for that particular function. And if the more specialized and modified flowers, which gradually fitted their forms and the position of their honey-glands to the forms of the bees or butterflies, showed a natural tendency to pass from yellow through pink and red to purple and blue, it would follow that the insects which were being evolved side by side with them, and which were aiding at the same time in their evolution, would grow to recognize these developed colors as the visible symbols of those flowers from which they could obtain the largest amount of honey with the least possible trouble. Thus it would finally result that the ordinary unspecialized flowers, which depended upon small insect riff-raff, would be mostly left yellow or white; those which appealed to rather higher insects would become pink or red; and those which laid themselves out for bees and butterflies, the aristocrats of the arthropodous world, would grow for the most part to be purple or blue.

Now, this is very much what we actually find to be the case in nature. The simplest and earliest flowers are those with regular, symmetrical, open cups, which can be visited by any insects whatsoever; and these are in large part yellow or white. A little higher are the flowers with more or less closed cups, whose honey can only be reached by more specialized insects; and these are oftener pink or reddish. More profoundly modified are those irregular one-sided flowers which have assumed special shapes to accommodate bees, or other specific honey-seekers; and these are often purple and not unfrequently blue. Highly specialized in another way are the flowers whose petals have all coalesced into a tubular corolla; and these might almost be said to be purple or blue. And, finally, highest of all are the flowers whose tubular corolla has been turned to one side, thus combining the united petals with the irregular shape; and these are almost invariably purple or blue. I shall proceed in the sequel to give examples.

One may say that the most profoundly modified of all existing flowers are the families of the composites, the labiates, the snapdragons, and the orchids. Now these are exactly the families in which blue and purple flowers are commonest; while in all of them, except the composites, white flowers are rare, and unmixed yellow flowers almost unknown. But perhaps the best way to test the principle will be to look at one or two families in detail, remembering of course that we can only expect approximate results, owing to the natural complexity of the conditions. Not to overburden the subject with unfamiliar names I shall seldom go beyond the limits of our own native English flora.

The roses form a most instructive family to begin with. As a whole they are not very highly developed, since all of them have simple, open, symmetrical flowers, generally with five distinct petals. But of all the rose tribe, as I have endeavored to show elsewhere, the potentilla group, including our common English cinquefoils and silver-weed, seem to make up the most central, simple, and primitive members. They are chiefly low creeping weeds, and their flowers are of the earliest pattern, without any specialization of form, or any peculiar adaptation to insect visitors. Now, among the potentilla group, nearly all the blossoms are yellow, as are also those of the other early allied forms, such as agrimony and herb-bennet. Almost the only white potentillas in England are the barren strawberry and the true strawberry, which have diverged more than any other species from the norma of the race. Water-avens, however, a close relative of herb-bennet, has a dusky purplish tinge; and Sir John Lubbock notes that it secretes honey, and is far oftener visited by insects than its kinsman. The bramble tribe, including the blackberry, raspberry, and dewberry, have much larger flowers than the potentillas, and are very greatly frequented by winged visitors. Their petals are pure white, often with a pinky tinge, especially on big well-grown blossoms. But there is one low, little-developed member of the blackberry group, the stone-bramble, with narrow, inconspicuous petals of a greenish yellow, merging into dirty white; and this humble form seems to preserve for us the transitional stage from the yellow potentilla to the true white brambles. One step higher, the cherries, apples, and pears have very large and expanded petals, white toward the centre, but blushing at the edges into rosy pink or bright red. Finally, the true roses, whose flowers are the most developed of all, have usually extremely broad pink petals (like those of our own dog-rose), which in some still bigger exotic species become crimson or damask of the deepest dye. They are more sought after by insects than any others of their family.

At the same time, the roses as a whole, being a relatively simple family, with regular symmetrical flowers of the separate type, have never risen to the stage of producing blue petals. That is why our florists cannot turn out a blue rose. It is easy enough to make roses or any other blossoms vary within their own natural limits, revert to any earlier form or color through which they have previously passed; but it is difficult or impossible to make them take a step which they have never yet naturally taken. Hence florists generally find the most developed flowers are also the most variable and plastic in color; and hence, too, we can get red, pink, white, straw-colored, or yellow roses, but not blue ones. This I believe is the historical truth underlying De Candolle's division of flowers into a xanthic and cyanic series.

Still more interesting, because covering a wider range of color, are the buttercup family, whose petals vary from yellow to every shade of crimson, purple, and blue. Here, the simplest and least differentiated members of the group are the common meadow buttercups, which, as everybody knows, have five open petals of a brilliant golden hue. Nowhere else is the exact accordance in color between stamens and petals more noticeable than in these flowers. There are two kinds of buttercup in England, however, which show us the transition from yellow to white actually taking place under our very eyes. These are the water crowfoot and its close ally the ivy-leaved crowfoot, whose petals are still faintly yellow toward the center, but fade away into primrose and white as the approach the edge. The clematis and anemone, which are more highly developed, have white sepals (for the petals are here suppressed), even in our English species; and exotic kinds varying from pink to purple are cultivated in our flower gardens. Columbines are very specialized forms of the buttercup type, both sepals and petals being brightly colored, while the former organs are produced above into long, bow-shaped spurs, each of which secretes a drop of honey; and various columbines accordingly range from red to purple and dark blue. Even the columbine, however, though so highly specialized, is not bilaterally but circularly symmetrical. This last and highest mode of adaptation to insect visits is found in larkspur, and still more developed in the curious monkshood. Now larkspur is usually blue, though white or red blossoms sometimes occur by reversion; while monkshood is one of the deepest blue flowers we possess. Sir John Lubbock has shown that a particular bumble-bee (*Bombus hortorum*) is the only north European insect capable of fertilizing the larkspur.

The violets are a whole family of bilateral flowers, highly adapted to fertilization by insects, and as a rule they are blue. Here, too, however, white varieties easily arise by reversion; while one member of the group, the common pansy, is perhaps the most variable flower in all nature.

Pinks do not display so wide a range in either direction. They begin as high up as white, and never get any higher than red or carnation. The small, undeveloped field species, such as the chick-weeds, stitchworts, and corn-spurries, have open flowers of very primitive character, and almost all of them are white. They are fertilized by miscellaneous small flies. But the campions and true pinks have a tubular calyx, and the petals are raised on long claws, while most of them also display special adaptations for a better class of insect fertilization in the way of fringes or crowns on the petals. These higher kinds are generally pink or red. Our own beautiful purple English corn-cockle is a highly developed campion, so specialized that only butterflies can reach its honey with their long tongues, as the nectaries are situated at the bottom of the tube. Two other species of campion, however, show us interestingly the way in which variations of color may occur in a retrograde direction even among highly evolved forms. One of them, the day lychnis, has red, scentless flowers opening in the morning, and it is chiefly fertilized by diurnal butterflies. But its descendant, the night lychnis, has taken to fertilization by means of moths; and as moths can only see white flowers, it has become white, and has acquired a faint perfume as an extra attraction. Still, the change has not yet become fully organized in the species, for one may often find a night lychnis at the present time which is only pale pink, instead of being pure white.

The only other family of flowers with separate petals which I shall consider here is that of the pea-blossoms. These are all bilateral in shape, as everybody knows; but the lower and smaller species, such as the medick, lotus, and lady's fingers, are usually yellow. So also are broom and gorse. Among the more specialized clovers, some of which are fertilized by bees alone, white, red, and purple predominate. Even with the smaller and earlier types, the most developed species, like lucerne, are likewise purple. But in the largest and most advanced types, the peas, beans, vetches, and scarlet runners, we get much brighter and deeper colors, often with more or less tinge of blue. In the sweet-peas and many others, the standard frequently differs in hue from the keel or wings—a still further advance in heterogeneity of coloration. Lupines, sainfoin, everlasting pea, and wistaria are highly evolved members of the same family, in which purple, lilac, mauve, or blue tints become distinctly pronounced.

When we pass on, however, to the flowers in which (as in this harebell) the petals have all coalesced into a tubular or campanulate corolla, we get even more striking results. Here, where the very shape at once betokens high modification, yellow is a comparatively rare color (especially as a ground-tone, though it often comes out in spots or patches), while purple and blue, so rare elsewhere, become almost the rule. For example, in the great family of the heaths, which is highly adapted to insect fertilization, more particularly by bees, purple and blue are the prevailing tints, so much so that, as we have all noticed a hundred times over, they often color whole tracts of hillside together. So far as I know, there are no really yellow heaths at all. The bell-shaped blossoms mark at once the position of the heaths with reference to insects; and the order, according to Mr. Bentham,

supplies us with more ornamental plants than any other in the whole world.

It is the same with the families allied to my harebell here. They are, in fact, for the most part, larger and handsomer blossoms of the same type as the heaths; and the greater number of them, like the harebell itself and the Canterbury bell, are also deep blue. Rampion and sheep's bit, also blue, are clustered heads of similar blossoms. The little blue lobelia of our borders, which is bilateral as well as tubular, belongs to a closely related tribe. Not far from them are the lilac scabious, the blue devil's bit, and the mauve teasel. Among all these very highly evolved groups blue distinctly forms the prevalent color.

The composites, to which belong the daisies and dandelions, also give us some extremely striking evidence. Each flower-head here consists of a number of small florets, crowded together so as to resemble a single blossom. So far as our present purpose is concerned, they fall naturally into three groups. The first is that of the dandelions and hawkweeds, with open florets, fertilized, as a rule, by very small insects; and these are generally yellow, with only a very few divergent species. The second is that of the thistle-heads, visited by an immense number of insects, including the bees; and these are almost all purple, while some highly evolved species, like the cornflower or bluebottle and the true artichoke, are bright blue. The third is that of the daisies and asters, with tubular central florets and long, flattened outer rays; and these demand a closer examination here.

The central florets of the daisy tribe, as a rule, are bright golden, a fact which shows pretty certainly that they are descended from a common ancester who was also yellow. Moreover, these yellow florets are bell-shaped, and each contain a pistil and five stamens, like any other perfect flower. But the outer florets are generally sterile; and instead of being bell-shaped they are split down one side and unrolled, so as to form a long ray; while their corolla is at the same time much larger than that of the central blossoms. In short, they are sterilized members of the compound flower-head, specially set apart for the work of display; and thus they stand to the entire flower-head in the same relation as petals do to the simple original flower. The analogy between the two is complete. Just as the petal is a specialized and sterilized stamen told off to do duty as an allurer of insects for the benefit of the whole flower, so the ray-floret is a specialized and sterilized blossom told off to do the self-same duty for the benefit of the group of tiny flowers which make up the composite flower-head.

Now the earliest ray-florets would naturally be bright yellow, like the tubular blossoms of the central disk from which they sprang. And to this day the ray-florets of the simplest daisy types, such as the corn marigold, the sunflower, and the ragwort, are yellow like the central flowers. In the camomile, however, the ox-eye daisy, and the mayweed, the rays have become white; and this, I think, fairly establishes the fact that white is a higher development of color than yellow; for the change must have been made in order to attract special insects. Certainly, such a differentiation of the flowers in a single head cannot be without a good purpose. In the true daisy, again, the white rays become tipped with pink, which sometimes rises almost to rose-color; and this stage is exactly analogous to that of apple-blossom, which similarly halts on the way from white petals to red. In the asters and Michaelmas daisies we get a further advance to purple, lilac, and mauve, while both in these and in the chrysanthemums true shades of blue not infrequently appear. The cinerarias of our gardeners are similar forms of highly developed groundsels from the Canary Islands.

I must pass over the blue tubular gentians and periwinkles, with many other like cases, for I can only find room for two more families. One of these, the borage kind, has highly modified flowers, with a tube below and spreading lobes above; in addition to which most of the species possess remarkable and strongly developed appendages to the corolla, in the way of teeth, crowns, hairs, scales, parapets, or valves. Of the common British species alone, the forget-me-nots are clear sky-blue with a yellow eye; the viper's bugloss is at first reddish purple, and afterwards a deep blue; the lungwort is also dark blue, and so are the two alkanets, the true bugloss, the madwort, and the familiar borage of our claret-cup, though all of them by reversion occasionally produce purple or white flowers. Houndstongue is purple-red, and most of the other species vary between purple and blue; indeed, throughout the family most flowers are red at first and blue as they mature. Of these, borage at least is habitually fertilized by bees, and I believe the same to be partially true of many of the other species. The second highly evolved family to which I wish to draw attention is that of the labiates—perhaps the most specialized of any so far as regards insect fertilization. Not only are they tubular, but they are very bilateral and irregular indeed, displaying more modification of form than any other flowers except the orchids. Almost all of them are purple or blue. Among the best-known English species are thyme, mint, marjoram, sage, and basil, which I need hardly say are great favorites with bees. Ground-ivy is bright blue; catmint, pale blue; prunella, violet-purple; and common bugle, blue or flesh-color. Many of the others are purple or purplish.* It must be added that in both these families the flowers are very liable to vary within the limit of the same species: and red, white, or purple specimens are common in all the normally blue kinds.

Sometimes, indeed, we may say that the new color has not yet begun to fix itself in the species, but that the hue still varies under our very eyes. Of this the little milkwort (a plant of the type with separate petals) affords an excellent example, for it is occasionally white, usually pink, and not infrequently blue; so that in all probability it is now actually in course of acquiring a new color. Much the same thing happens with the common pimpernel. Its ancestral form is probably the woodland loosestrife, which is yellow; but pimpernel itself is usually orange-red, while a blue variety is frequent on the Continent, and sometimes appears in England as well. Every botanist can add half-a-dozen equally good instances from his own memory.

So far I have spoken only of what the ladies would call self-color, as though every flower were of one unvaried hue throughout. I must now add a few words on the subject of the spots and lines which so often variegate the petals in certain species. On this subject, again, Mr. Wallace's hint is full of meaning. Everywhere in nature, he points out, spots and eyes of color appear on the most highly modified parts, and this rule applies most noticeably to the case of petals. Simple regular flowers, like the buttercups and roses, hardly ever have any spots or lines: but in very modified forms, like the labiates and the orchids, they are extremely common. The scrophularineous family, to which the snapdragon belongs, is one most specially adapted to insects, and even more irregular than that of the labiates; and here we find the most singular effects produced by dappling and mixture of colors. The simple yellow mullein, it is true, has no such spots or lines, nor have even many of the much higher blue veronicas; but in the snapdragons, the foxglove, the toadflax, the ivy-linaria, the eyebright, and the calceolarias, the intimate mixture of colors is very noticeable. In the allied tropical bignonias and gloxinias we see much the same distribution of hues. Many of the family are cultivated in gardens on account of their bizarre and fantastic shapes and colors. As to the orchids, I need hardly say anything about their wonderfully spotted and variegated flowers. Even in our small English kinds the dappling is extremely marked, especially upon the expanded and profoundly modified lower lip; but in the larger tropical varieties the patterns are often quaint and even startling in their extraordinary richness of fancy and apparent capriciousness of design. Mr. Darwin has shown that their adaptations to insects are more intimate and more marvelous than those of any other flowers whatsoever.

Structurally speaking, the spots and lines on petals seem to be the direct result of high modification; but functionally, as Sprengel long ago pointed out, they act as honey guides, and for this purpose they have no doubt undergone special selection by the proper insects. Lines are comparatively rare on regular flowers, but they tend to appear as soon as the flower becomes even slightly bilateral, and they point directly toward the nectaries. The geranium family affords an excellent illustration of this law. The regular forms are mostly uniform in hue; but many of the South African pelargoniums, cultivated in gardens and hot houses, are slightly bilateral, the two upper petals standing off from the three lower ones; and these two become at once marked with dark lines which are in some cases scarcely visible, and in others fairly pronounced. From this simple beginning one can trace a gradual progress in heterogeneity of coloring, till at last the most developed bilateral forms have the two upper petals of quite a different hue from the three lower ones, besides being deeply marked with belts and spots of dappled color. In the allied tropæolum or Indian cress (the so-called nasturtium of old-fashioned gardens, though the plant is really no more related to the water cress and other true nasturtiums than we ourselves are to the great kangaroo) this tendency is carried still further. Here, the calyx is prolonged into a deep spur, containing the honey, inaccessible to any but a few large insects; and toward this spur all the lines on the petals converge. Sir John Lubbock observes that without such conventional marks to guide them, bees would waste a great deal of time in bungling about the mouths of flowers; for they are helpless, blundering things at an emergency, and never know their way twice to the same place if any change has been made in the disposition of the familiar surroundings.

Finally, there remains the question—why have some flowers green petals? This is a difficult problem to attack at the end of a long paper; and indeed it is one of little interest for ninety-nine people out of a hundred; since the flowers with green petals are mostly so small and inconspicuous that nobody but a professional botanist ever troubles his head about them. The larger part of the world is somewhat surprised to learn that there are such things as green flowers at all; though really they are far commoner than the showy-colored ones. Nevertheless, lest I should seem to be shirking a difficulty altogether, I shall add that I believe green petals to be in almost every case degraded representatives of earlier yellow or white ones. This belief is clean contrary to the accepted view, which represents the green, wind-fertilized blossoms as older in order of time than their colored insect-fertilized allies. Nevertheless, I think all botanists will allow that such green or greenish flowers as the hellebores, the plantains, the lady's mantle, the salad burnet, the moschatel, the twayblade, and the parsley-piert are certainly descended from bright-hued ancestors, and have lost their colors on their petals though acquiring the habit of wind-fertilization or self-fertilization. Starting from these, I can draw no line as I go downward in the scale through such flowers as knawel, goose-foot, dog's mercury, nettle, and arrowgrass, till I get to absolutely degraded blossoms like glasswort, callitriche, and pondweed, whose real nature nobody but a botanist would ever suspect. Whether the catkins, the grasses, and the sedges were ever provided with petals I do not venture to guess; but certainly wherever we find the merest rudiment of a perianth, I am compelled to believe that the plant has descended from bright-colored ancestors, however remotely. And when we look at the very degraded blossoms of the spurges which we know by the existence of intermediate links to be derived from perianth-bearing forefathers, the possibility, at least, of this being also true of catkins and grasses cannot be denied. So far as I can see, the conifers and cycads are the only flowering plants which we can be quite sure never possessed colored and attractive petals. But this digression is once more only intended for the scientifically minded reader.

If the general principle here put forward is true, the special colors of different flowers are due to no mere spontaneous accident, nay, even to no meaningless caprice of the fertilizing insects. They are due in their inception to a regular law of progressive modification; and they have been fixed and stereotyped in each species by the selective action of the proper beetles, bees, moths, or butterflies. Not only can we say why such a color, once happening to appear, has been favored in the struggle for existence, but also why that color should ever make its appearance in the first place, which is a condition precedent to its being favored or selected at all. For example, blue pigments are often found in the most highly developed flowers, because blue pigments are a natural product of high modification—a simple chemical outcome of certain extremely complex biological changes. On the other hand, bees show a marked taste for blue, because blue is the color of the most advanced flowers; and by always selecting such where possible, they both keep up and sharpen their own taste, and at the same time give additional opportunities to the blue flowers, which thus insure proper fertilization. I believe it ought always to be the object of naturalists in this manner to show not only why such and such a "spontaneous" variation should have been favored whenever it occurred, but also to show why and how it could ever have occurred at all.—*Grant Allen, in Cornhill Magazine.*

* Our English archangels and a few others are yellow. Such cases of reversion are not uncommon, and are doubtless due to special insect selection in a retrograde direction.

THE ADMINISTRATION OF ANÆSTHETICS.

A valuable paper, by M. Paul Bert, on the administration of anæsthetics, has recently been read before the Academy of Sciences (*Comptes Rendus*, vol. xciii., p. 768). M. Bert finds by experiment that if an anæsthetic be mixed with variable quantities of atmospheric air there comes a point at which an animal made to breathe such an atmosphere exhibits anæsthesia, and that this point bears a definite relation to the point at which the anæsthetic proves fatal. In experiments made upon dogs, mice, and sparrows, using chloroform, ether, amylene, and bromide and chloride of ethyl, it was found that the fatal dose was double that required to produce insensibility. In the case of protoxide of nitrogen the ratio is one to three. The result shows that chloroform acts not by the quantity inhaled, but by the amount of air mixed with it. This important result, although the experiments had not then been made upon mankind, shows that in all probability careful observation made by those who have the adminstration of chloroform in their hands may reduce its use to a minimum of risk, and that in the future it may be employed with scientific precision. An instrument by which the amount of admixture of air and chloroform could be easily regulated before inhalation seems therefore to be a desideratum.

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